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JOURNAL OF SCIENCE

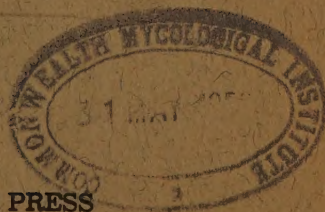
A Quarterly of Research



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ABSTRACTS OF DOCTORAL DISSERTATIONS

Accepted July 1, 1954 - June 30, 1955

These abstracts are arranged in alphabetical order by names of the authors. A footnote to each abstract carries the serial number of the candidate's dissertation, the date of acceptance by the Graduate College, the academic degrees held by him, his academic position (if any) in the several departments and research institutes of Iowa State College, and the name of the chairman of his committee.

The following summaries and indices may prove helpful to those interested in tabulations and to those who wish to examine groups of abstracts of theses in the same or related fields.

1. DOCTORAL DISSERTATIONS ACCEPTED JULY 1, 1954 - June 30, 1955 = 112.
Number of Doctor of Philosophy degrees conferred on candidates on whom first degrees were conferred by:

- a. Institutions other than Iowa State College = 97.
b. Iowa State College = 15.

2. INDEX TO THESES BY DEPARTMENTS. Double indexing is used in those cases where two departments are jointly responsible. The departments are arranged alphabetically. Under each department are listed alphabetically the names of the authors.

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A graduate school can function only where there is adequate opportunity for research. The existence on the campus of Iowa State College of six research institutes, well integrated into the college programs is in large measure responsible for the growth of the graduate work. These institutes have frequently assumed the responsibility of providing research facilities necessary for the doctoral candidates in their respective fields. It is obvious that these institutes carry on a significant part of their research by use of workers who are in a sense apprentices in research. Under the name of each institute is given the total number of theses for which research facilities were afforded, and an alphabetical list of the authors of sponsored theses.

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APPARENT AND PARTIAL MOLAL VOLUMES OF SOME
RARE EARTH SALTS IN AQUEOUS SOLUTIONS¹BUELL OSCAR AYERS²
Department of Chemistry

The specific gravities, apparent molal volumes, and partial molal volumes of aqueous solutions of the chlorides and nitrates of lanthanum, neodymium, erbium, and ytterbium have been determined for concentrations up to about 0.3 molal. The specific gravities were determined by a modification of the magnetically controlled float method originated by Lamb and Lee (1) and improved by Geffcken, Beckmann, and Kruis (2), and MacInnes, Dayhoff, and Ray (3). Apparent molal volumes for each salt, as calculated from the measured specific gravities, were expressed as a five parameter power series in the square root of the molal concentrations. Partial molal volumes were obtained by differentiation of the empirical equations for the apparent molal volumes. The equations for the apparent molal volumes were of the form

$$\phi = \phi^0 + a_1 m^{1/2} + a_2 m + a_3 m^{3/2} + a_4 m^2,$$

and those for the partial molal volumes were of the form

$$\bar{V}_2 = \bar{V}_2^0 + (3/2)a_1 m^{1/2} + 2a_2 m + (5/2)a_3 m^{3/2} + 3a_4 m^2.$$

The adjustable parameters were evaluated as follows:

	ϕ^0	a_1	a_2	a_3	a_4
LaCl ₃	13.86	36.044	-87.540	134.52	-75.634
La(NO ₃) ₃	48.31	52.961	-224.87	586.07	-544.48
NdCl ₃	10.46	21.129	-17.554	5.7320	5.3420
Nd(NO ₃) ₃	44.44	46.171	-95.234	147.50	-91.923
ErCl ₃	11.80	23.292	-54.438	116.22	-93.172
Er(NO ₃) ₃	45.68	18.327	-2.6032	-41.929	53.567
YbCl ₃	9.25	22.569	-24.425	8.9836	12.628
Yb(NO ₃) ₃	43.73	19.590	-2.9351	-50.955	65.590

The apparent and partial molal volumes of the rare earth salts were found to deviate from the simple limiting laws at low concentrations. The deviation appears to be greater for heavy rare earth salts than for salts of the lighter elements. This change is in the direction to be expected from the increasing extent of hydrolysis and greater stability of complex ion formation with increasing atomic number.

The apparent molal volumes of the rare earth salts at infinite dilution do not vary regularly with atomic number but appear to fall into two series. Data obtained from this investigation indicate that lanthanum and neodymium salts are members of one series while erbium and ytterbium salts are members of a second series. The appearance of two series may result from a change in the hydration number of the rare earth ions. As the ions become larger, with decreasing atomic number, a second coordination number may become possible, resulting in an equilibrium being established between hydrated rare earth ions having different coordination numbers. A decrease in the total volume of the solvent with an increase in coordination number would then lead to two series in the limiting apparent molal volumes. The apparent molal volumes at infinite dilution for lanthanum and neodymium salts should thus be lower than would be predicted if they were members of the series having a lower coordination number.

Apparent molal volumes were found to increase more rapidly with increasing concentration for lanthanum nitrate and neodymium nitrate than for the other salts investigated. This behavior may also be due to an equilibrium between lanthanum ions or

¹Doctoral thesis no. 1602, submitted November 15, 1954. Chairman of Committee, Frank H. Spedding, Department of Chemistry.

²A.B. Howard Payne College, Brownwood, Texas, 1940. Research Assistant, Institute for Atomic Research.

neodymium ions having two coordination numbers. The chloride ions, being roughly of the same size as the water molecules, should be able to displace a water molecule from the hydration shell of the cation without greatly disturbing other water molecules in the shell. The more bulky nitrate ion should have a greater steric effect on the water molecules surrounding the ions having the larger and presumably less stable coordination number, driving the equilibrium in the direction of the smaller coordination number. As a result of this change in equilibrium, the apparent molal volumes would tend to shift toward the higher values to be expected for the smaller coordination number. Since the larger coordination number should be more stable for the lanthanum ion than for the neodymium ion, the shift in the apparent molal volumes of lanthanum nitrate should be less pronounced.

At the present time there are not sufficient data for definite conclusions to be reached. The proposed explanation of the anomalies in the apparent molal volumes leads to qualitative agreement with the experimental results, but additional data are needed for the other rare earth salts. Measurements of apparent molal volumes should be extended to include the chlorides and nitrates of all the rare earth series. In addition, data for salts of different anion valence types, such as the sulfates, would be useful.

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2. Geffcken, W., C. Beckman, and A. Kruis. *Z. physik. Chem.* B20:398. 1933.
3. MacInnes, D.A., M.O. Dayhoff, and B.R. Ray. *Rev. Sci. Instr.* 22:642. 1951.

APPLICATION OF SEVERAL ECONOMETRIC TECHNIQUES TO A THEORY OF DEMAND WITH VARIABLE TASTES¹

ROBERT L. BASMANN²

Department of Economics and Sociology

Existing theory of consumer demand does not contain a body of theorems purporting to explain the consumption behavior of individuals when their preferences are changed, either autonomously or by advertising and other forms of selling effort. In view of the importance of advertising in the modern economy, it is desirable that such a body of theorems be worked out. The objective of this study is the formulation of a theory of consumer demand with variable preferences; the governing criterion is that the theory be applicable in econometric demand analysis.

The assumption that the individual consumer has only one unique ordinal utility function is replaced by the assumption that he has a whole family of ordinal utility functions; advertising expenditures by sellers of commodities are assumed to determine which one of these ordinal functions is maximized at any given time. From these assumptions are derived a number of theoretical relations expressing restraints which measurements defining advertising elasticities of demand are constrained to obey. It is shown that advertising elasticities are weighted averages of elasticities of substitution between goods in consumption, the weights being measurements defining advertising elasticities of marginal utilities. Methods of estimating elasticities of the marginal utilities are suggested.

In the second part estimates of empirical advertising elasticities of demand for tobacco are presented. It is found that the consumption of tobacco is inelastic with respect to tobacco advertising expenditure. An estimate of the elasticity of marginal utility of tobacco with respect to advertising expenditure is obtained; this estimate indicates that the marginal utility of tobacco is inelastic with respect to tobacco advertising. The computation of these estimates provides an example of how the theory of consumer demand with variable preferences can be applied to econometric demand analysis.

¹Doctoral thesis no. 1671, submitted June 3, 1955. Chairman of Committee, G. Tintner, Department of Economics and Sociology.

²B.S., Iowa State College, Ames, Iowa, 1950. M.S. *ibid.*, 1953. Research Associate, Graduate Assistant.

REACTIONS OF COBALAMINS WITH SEVERAL PROTEIN PREPARATIONS¹WALLACE R. BAURIEDEL²

Department of Chemistry

The reactions of vitamins B₁₂ and B_{12b} with protein material were investigated for the purpose of identifying the structural features of the cobalamin molecule which participate in these reactions, and the possible structures of the protein binding sites. It has been reported that vitamin B_{12b} reacts with histidine or ammonia to form what have been termed cobalichromes, i.e., replacement of the aquo- group of vitamin B_{12b} with a basic ligand. A preliminary spectrophotometric investigation indicated that of twenty common amino acids, only histidine entered into cobalichrome formation at pH 4.5 with vitamin B_{12b}. The histidine-vitamin B_{12b} reaction was found to be markedly pH dependent. The equilibrium constant for the reaction was estimated to be 4×10^5 liters per mole at pH 7 and 25°C. Vitamin B₁₂ was not observed to react with any of the amino acids examined. Thus, the proposal that cobalamins are bound to proteins via a cobalichrome linkage fails to account for the reported reactions of vitamin B₁₂ with protein.

A partial dialysis method was devised to determine the extent of the reactions between cobalamins and proteins. By constructing a dialysis cell in which the volume, membrane area and agitation were held constant, reproducible short-term dialysis of cobalamins was obtained. The use of three identical dialysis cells allowed triplicate determinations to be made. Cobalamins labeled with Co⁶⁰ were used for this work, and a dependable method of radioassay of liquid samples was devised. It was demonstrated that the rates of dialysis of vitamins B₁₂ and B_{12b} in buffered solutions were identical and could be adequately expressed as functions of time, temperature, and concentration. Thus, the amount of cobalamin bound (rendered nondialysable) by a given concentration of protein could be determined under mild, controllable conditions and without the use of ambiguous microbiological systems.

It was found that blood serum bound unexpectedly large amounts of vitamin B_{12b}, but only small, roughly physiological amounts of vitamin B₁₂. By salt fractionation and by paper electrophoresis it was demonstrated that apparently all of the serum protein components participated in the binding of vitamin B_{12b}. Heat denaturation increased the vitamin B_{12b}-binding capacity of serum. The reaction was inhibited by increasing the hydrogen ion concentration.

A similar binding of vitamin B_{12b} but not of vitamin B₁₂ was observed for hemoglobin, globin, purified serum albumin, lactalbumin, and crystalline trypsin and pepsin. It was concluded that the reaction of vitamin B_{12b} with these preparations and with serum may be the result of cobalichrome formation, possibly with exposed or available histidine side chains.

Lysozyme was shown by partial dialysis and by paper electrophoresis to have no binding-activity for either form of the vitamin, possibly indicating that the histidine side chain of lysozyme is not accessible for cobalichrome formation of vitamin B_{12b}.

A gastric mucosal extract exhibiting high cobalamin binding activity was prepared from a commercial dried stomach preparation (Ventriculin) by aqueous extraction and successive salt and alcohol precipitation of the protein constituents. The gastric extract was found by the partial dialysis method to bind approximately equal amounts of vitamins B₁₂ and B_{12b}. Addition to the gastric extract of an excess of either form of the vitamin provided an essentially complete block for the binding of the other form. It was concluded that apparently both forms of the vitamin react at the same site on the binding substance present in the gastric extract, and that the reaction involves a reactive group possessed by both forms of the vitamin.

The partial dialysis method proved to be more versatile than previously used methods for examining the reaction of vitamin B₁₂ with gastric extracts. It was found that the binding of vitamin B₁₂ by the gastric extract was essentially unaffected by changes in buffer anion and concentration, and by changes of hydrogen ion concentrations from pH 2 to pH 10. Progressively less binding occurred as the pH of the reaction mixture was raised from pH 10 to pH 12.

¹Doctoral thesis no. 1614, submitted December 6, 1954. Chairman of Committee, L.A. Underkofler, Department of Chemistry.

²B.S., Iowa State College, Ames, Iowa, 1949. M.S., *ibid.*, 1952. Associate, Chemistry, Veterinary Medicine Research Institute.

The reaction was unaffected by heating at 60°C, but the binding capacity of the gastric extract was progressively decreased by heating at 100°C for increasing periods of time. The presence of cobaltous chloride and benzimidazole did not appear to inhibit the binding of vitamin B₁₂ by the gastric extract.

The reaction between vitamin B₁₂ and the gastric extract was found to be partially inhibited by the presence of excess cyanide at pH 10 or above, but not at pH 6.6. The order of addition of reactants had no effect, i. e., dicyanocobalamin also reacted with the gastric extract. These results suggest that coordination with the cobalt at the position taken by the second cyano- group may be an essential feature of the cobalamin-gastric extract reaction. In support of this, evidence was obtained which indicated that the cyano- group of vitamin B₁₂ was not displaced by the reaction of vitamin B₁₂ with the gastric extract, but that this cyano- group remained in a photo-labile position in the resulting product. It was concluded that the above observations are consistent with the proposal that the gastric extract-vitamin B₁₂ reaction involves displacement of the benzimidazole group by a group which enters into coordination with the cobalt atom of vitamin B₁₂.

The nature of the reactive site possessed by the gastric extract remains undetermined. The suggestion that sulphydryl groups may participate in the reaction was shown to be unlikely, for an excess of p-chloromercuribenzoic acid had no effect on the binding of vitamin B₁₂ by the gastric extract.

REGULARIZATION OF CERTAIN SYSTEMS OF DIFFERENTIAL EQUATIONS¹

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Systems of differential equations of the type

$$\frac{d^2x}{dt^2} - 2\lambda(x, y) \frac{dy}{dt} = \Omega_x(x, y) \quad (1)$$

$$\frac{d^2y}{dt^2} + 2\lambda(x, y) \frac{dx}{dt} = \Omega_y(x, y)$$

often arise in problems in dynamics. In some cases the functions $\Omega(x, y)$, $\Omega_x(x, y)$, $\Omega_y(x, y)$ have discontinuities at certain points of the xy-plane. Since the conditions necessary for the establishment of the existence theorem cease to hold at such points, they are called singular points of the system of differential equations. In some cases a transformation of variables will give a new system of differential equations equivalent to the original system but without one or more of these singular points. That is, the new equations will possess solutions defined at points corresponding to points of discontinuity for the first system. This process of removing singular points is known as "regularization."

A classical example of regularization is the removal of the singular points arising from collision in the system of differential equations for the restricted problem of three bodies (1, p. 269). Regularization for that problem was carried out by Levi-Civita (1, p. 692-693) and G. D. Birkhoff (1, p. 693-694).

Hill's (2) equations arising in a problem of celestial mechanics are of the form (Eqs. 1). This system has one singular point and may be regularized by a transformation similar to that introduced by Levi-Civita.

In this thesis the equations of motion for certain restricted problems of n-bodies (3), with $n \geq 4$, are regularized for three singular points by using transformations of the type employed by Birkhoff twice in succession. For $n = 4$ the system is completely regularized, since only three singular points exist. For $n \geq 5$ no further regularization

¹Doctoral thesis no. 1606, submitted November 24, 1954. Chairman of Committee, J. J. L. Hinrichsen, Department of Mathematics.

²A. B., Sioux Falls College, Sioux Falls, South Dakota, 1941. M. S., Iowa State College, Ames, Iowa, 1947. Instructor.

can be accomplished by repeating the Birkhoff type transformation, because every singular point for the original system of equations goes into two new singular points for the new system of equations by this type of transformation. Hence, after the Birkhoff type transformation has been used twice, the original singular point has gone into four singular points for the final system of equations, and the Birkhoff type transformation can regularize the equations at only two points.

Finally, the system of equations

$$\begin{aligned}\frac{d^2x}{dt^2} - 2\lambda(x, y) \frac{dy}{dt} &= -\frac{nx}{r^{n+2}}, \\ \frac{d^2y}{dt^2} + 2\lambda(x, y) \frac{dx}{dt} &= -\frac{ny}{r^{n+2}},\end{aligned}\quad (2)$$

where $r = \sqrt{x^2 + y^2}$, and n is in the interval $-2 < n < 2$, may be regularized by a transformation of the type $z = w^k$. When $-2 < n < 0$ one can choose $k = 2$, and for $0 < n < 2$ $k = \frac{4}{2-n}$. While this selection for values of k regularizes equations (2) for all values of n in the interval $-2 < n < 2$, there is a better choice for k if n is in the interval $1 < n < 2$. When n lies in this last interval, the choice $k = \frac{2}{2-n}$ is possible.

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3. Hinrichsen, J.J.L. The libration points in an n -body problem. *American Math. Monthly* 50:231. 1943.

GENETIC RELATIONSHIPS BETWEEN MILK PRODUCTION AND GROWTH IN HOLSTEINS¹

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The investigation was undertaken to get additional evidence concerning the genetic relations between milk production and certain body measurements, which have previously been found associated with meat production.

The data consisted of six body measurements, and milk production on 334 females and their dams, birth weight on 295 of them, and the six-month body measurements on 218 dam-son pairs from the Iowa State College Holstein herd. The measurements were taken during the period from 1930 to 1953. The measurements were: wither height, chest depth, body length, heart girth, paunch girth, and weight. Each of these was taken at six months, one year, two years, three years, four years, five years, and seven years of age. The birth weight was taken at four days of age. The measure used for milk production was twice-a-day, 305-day, mature equivalent, 3.5 per cent fat corrected milk.

All calculations are based in intra-sire analyses.

Heritabilities were obtained by doubling the intra-sire regression of offspring on dam. The heritabilities increased with increasing age.

It was found that simultaneous selection for increased milk production and improved meat quality, as indicated by body conformation, would be impractical. However,

¹Doctoral thesis no. 1601, submitted October 18, 1954. Chairman of Committee, L. N. Hazel, Department of Animal Husbandry.

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simultaneous selection for weight for age and milk production should prove advantageous; particularly since it has already been shown that Holstein steers can be used economically in the feed lot.

Although no direct effort was made to analyze the influence on growth into general, group, and specific factors, there was strong evidence to support the classifications given by Touchberry (1951). There was also evidence that the group and specific factors are not fully expressed until later stages of growth.

A study of the correlations involving body measurements only indicates that later stages of growth are more affected by group and specific factors than early stages are.

The phenotypic correlations between milk production of the dam and measurements of the daughter were consistently higher than the corresponding correlations between production of the daughter and measurements of the dam. This condition existed for all measurements at all three ages. It was therefore concluded that some nongenetic factor was affecting the correlations involving dam's production. Because of this apparent nongenetic influence the genetic correlations involving milk production were calculated in two ways. The first is that presented by Hazel (1943). The second is a modification of the first. The modification is the use of only one correlation in the numerator. The correlations chosen are the ones between daughter's production and dam's measurements.

An effort was made to determine whether the nongenetic correlation could be attributed to conditions peculiar to a particular lactation. The answer was sought by comparing (a) the correlation between the daughter's six-months size and production of the dam in the lactation begun at the birth of the daughter with (b) the correlation between the daughter's size at six months and the dam's average production in the $(n - 1)$ other lactations. It was concluded that most, if not all, of the effect was due to factors peculiar to the lactation begun at the birth of the daughter.

A further study was undertaken to find out whether the nongenetic effect on the daughter was expressed prenatally. This question was approached by considering the relations existing between the daughter's birth weight and (a) dam's productions in the contemporary lactation and (b) the dam's average in her $(n - 1)$ other lactations. The effect is evidently not expressed prenatally.

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EFFECTS OF VARIOUS DIETARY HAY-CONCENTRATE RATIOS ON NUTRIENT UTILIZATION AND PRODUCTION RESPONSES OF DAIRY COWS¹

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The inception and development of the ideas embodied in this study arose from the need for expanded research in roughage evaluation and utilization. The nature of the experimental design employed in this research also provided data for a study of the input-output relationships in milk production. The economic interpretations of the data are treated elsewhere and the thesis is confined to the analyses and interpretations stemming from the nutritional and physiological concepts.

This research with its consideration of the producing ability of the cow, the variously arbitrarily determined levels of feeding, the widely different hay to concentrate

¹Doctoral thesis no. 1665, submitted June 1, 1955. Chairman of Committee, N. L. Jacobson, Department of Animal Husbandry.

²B.S., Iowa State College, Ames, Iowa, 1950. M.S., Pennsylvania State University, University Park, Penna., 1952. Graduate Assistant.

ratios and the digestibility trials provided the data which were approached in analyses from the following main directions:

1. The relationships among and the effects upon milk production of the initial producing ability of the cow, the feeding level, the hay to concentrate ratio and the changes in body weight.
2. The efficiency of milk production.
3. The comparison and evaluation of feeding standards.
4. The digestibility study using the chromic oxide technique.
5. The excretion pattern of chromic oxide.

Four rations of hay and concentrates in the ratios of 75:25, 55:45, 35:65, and 15:85 were fed to 36 lactating Holstein cows for a 26-week experimental period, following a 60-day preliminary period *post partum*. Each of the four rations was fed at a high, a medium, and a low level. The cows were divided into high, medium, and low producing groups based on the production in the preliminary period. Three cows, one of each producing group, were randomly allotted to each of the 12 "hay to concentrate-feeding level" positions. For each cow the total feed energy requirement for production over the experimental period was predetermined and partitioned into 26 decreasing weekly quantities. Feeding was based on NE recommendations and the energy content of the feeds was calculated for various NE and TDN feeding standards on the basis of frequent proximate analyses of the feeds. Ration digestibility was determined for each cow by the chromic oxide technique and the daily fecal excretion pattern of the chromic oxide was investigated.

The differences in the ENE available for milk production at the three feeding levels were much greater than the corresponding differences in FCM production, which indicated that the ability of the animals exerted a greater influence upon production than did the intensity of feeding. Production in the preliminary period was highly correlated with that in the experimental period. The degree of production response to full feed during the post-experimental period indicated a relation to the magnitude of production in the preliminary period.

Weight changes during the initial five weeks of the experimental period were closely related to diet, but thereafter, particularly at the lower feeding levels, were largely independent of the ration.

The gross efficiencies of milk production for high, medium, and low cows arranged as to the level of feeding and as to ability were, respectively, 32.7, 34.4, and 34.8 per cent and 35.8, 33.8, and 32.2 per cent. The net efficiencies of milk production for high, medium, and low cows arranged as to the level of feeding and as to ability were, respectively, 55.0, 59.3, and 63.5 per cent and 62.6, 58.9, and 56.2 per cent.

The NE feeding standards demonstrated a definite superiority over the TDN standards as consistent evaluators of the productive energy derived from rations differing widely in their hay content. The production of a pound of 4 per cent FCM from the high to the low hay rations, respectively, required .36, .36, .37, and .35 therms as compared to .44, .40, .38, and .33 lb. TDN. At each hay to concentrate feeding ratio, the Fraps NE standard achieved the closest approximation to the recommended energy requirements for the production of a pound of 4 per cent FCM.

From the high to the low hay rations, the dry matter digestibilities were, respectively, 54.41, 58.80, 55.23, and 63.10 per cent. Dry matter digestibilities for high, medium, and low ability cows were 58.23, 58.13, and 57.18 per cent, respectively, and for high, medium, and low feeding levels were 57.63, 57.77, and 58.17 per cent, respectively.

In the digestibility study, the fecal excretion pattern of chromic oxide was of a diurnal nature. The maximum excretion of chromic oxide was observed in samples at 5 A.M. and 9 A.M. while the minimum excretion was observed in samples at 5 P.M. and 9 P.M. This typical diurnal excretion pattern was largely independent of the wide variation in the physical nature of the rations and of the feeding level.

THERMAL DECOMPOSITION OF CALCIUM SULFATE¹WALTER MICHAEL BOLLEN²

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The shortage of Frasch-minable sulfur reserves has led to consideration of other materials as sources of sulfur and sulfuric acid. Naturally occurring calcium sulfate, gypsum, and anhydrite have been considered and in fact used for more than 30 years. However, addition agents have invariably been added to lower the required decomposition temperature and decrease the thermal requirements. The purpose of the work of this thesis was the investigation of processes which would not require the addition of such agents. The maximum possible sulfur dioxide concentration in the dry off-gas from such a process would be 18.0 per cent, based on an over-all thermal efficiency of 100 per cent.

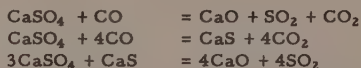
The majority of the investigations were with gypsum, but a few studies were also made with anhydrite. Two types of reactors were studied: a shaft furnace and a fluidized bed.

The work with the shaft furnace was limited to nominally oxidizing conditions; i.e. greater than the stoichiometric amount of air required for combustion was supplied. In the temperature range 2400°F to 2450°F a retention time of 6 1/2 hours was estimated to be required for 95 per cent desulfurization. However, it was not possible to operate with retention times greater than 2 1/2 to 3 hours because of fusion of the surface of the lumps and subsequent sticking of the charge. This fusion would start at about 2375°F. At 2250°F to 2350°F the estimated retention time for 95 per cent desulfurization was 30 hours. At temperatures greater than 2600°F the charge became completely molten but resolidified after a portion of the sulfur trioxide was expelled and completely plugged the shaft. One run in which reducing conditions were present produced an excellent unfused product which was 96 per cent desulfurized. The maximum temperature was 2500°F and the retention time was 4 hours. However, the effect of reducing conditions was not recognized until later work with the fluidizing bed, so further investigations under these conditions were not made with the shaft furnace.

The studies with the fluidized bed brought out the importance of the oxidation-reduction characteristics of the bed atmosphere. It was found that with 117 per cent or greater of the stoichiometric air supplied, only very slight desulfurization occurred at temperatures below fusion. However, as the amount of air supplied was decreased and reducing substances, notably carbon monoxide, appeared, desulfurization occurred with no fusion at temperatures above 2100°F.

If the air was decreased to less than 100 per cent of that stoichiometrically required, no appreciable oxygen was present and calcium sulfide formation accompanied the desulfurization and prevented complete desulfurization. Consequently, at a constant gas/air ratio maximum desulfurization (96 per cent desulfurization with a 120 minute retention time) was obtained with 100 per cent stoichiometric air, under which conditions both carbon monoxide and oxygen were present. The sulfide formed under reducing conditions could be rapidly oxidized to calcium oxide and sulfur dioxide by supplying an excess of air.

The reactions involved probably include:



The equilibrium constants for these and other possible reactions were computed over the temperature range of interest. The equilibrium constant for the last reaction above in the range 2000°F to 2400°F is favored by higher temperatures. Because of this, the amount of residual sulfide decreases and hence desulfurization increases with increasing temperature in this temperature range under reducing conditions.

¹Doctoral thesis no. 1571, submitted July 1, 1954. Chairman of Committee, G.L. Bridger, Department of Chemical Engineering.

²B.S., Oregon State College, Corvallis, Ore., 1947. M.S. *ibid.*, 1949. Graduate Assistant.

No fusion of particles was observed at temperatures as high as 2450°F when reducing conditions were present, although under oxidizing conditions temperatures of 2400°F caused serious fusion.

Work with anhydrite was limited to the temperature range 2250°F to 2350°F at 80 and 95 per cent of stoichiometric air supplied. Particle size studies were, however, made with this material. With -6+8 mesh particles, the desulfurization was slower than with gypsum under the same conditions, as would be expected since the gypsum is "opened up" by the dehydration process. The particle size studies presented a curious phenomenon. With -8+10 and -10+12 mesh particles the bed was about 600°F to 800°F cooler than with the -6+8 mesh particles at the same fluidizing gas inlet temperature. Consequently, the smaller particle sizes were least desulfurized. This occurred with both constant gas rate conditions and approximately constant bed porosity conditions suggesting an extreme effect of the particle size on the heat transfer characteristics of the fluidized bed.

This work demonstrates that sulfur or sulfur dioxide can be produced from the virtually unlimited supply of natural calcium sulfate without the use of addition agents. The desulfurization of calcium sulfate can be accomplished below its fusion temperature in either a reducing or alternately reducing and oxidizing atmosphere. Economically, it could not compete in the United States with Frasch-mined sulfur, but if these sulfur deposits become depleted such a process might be competitive with other sulfur producing processes, particularly if there existed a market for the by-product lime produced.

GROWTH AND MINERAL NUTRITION OF THE MAIZE ROOT TIP¹

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The specific problem in this study was to determine quantitative interrelations between growth of the maize root tip and the macro-nutrients therein. Attention was focused at the cellular level.

All growth and mineral nutrition studies were carried out on the apical 5 mm of the seedling root of an F₁ hybrid. Measurements of linear growth *in vivo* were made by noting the displacements of carborundum particles initially placed at 1 mm intervals on the apical portion of the roots.

One millimeter sections for cell counts and for analyses were cut from the root tip with a cutting jig. Cell counts were made in a haemocytometer after digestion with pectinase to separate the cells. The tissue for nitrogen and phosphorus determinations was ground at 0°C in 10 per cent TCA, and centrifuged to separate the soluble and insoluble fractions containing, respectively, soluble nitrogen and phosphorus, and protein bound phosphorus.

Potassium content was determined by wet ashing the tissue and analyzing on a flame photometer. Analyses of calcium and magnesium were made with a modification of the Cheng and Bray EDTA method.

In vitro growth of the individual sections was followed for brief periods by placing them on the raised center of a filter paper disk wet with nutrient solution. Aseptic cultures of the apical section were made in flasks. Varying levels of nitrogen, phosphorus or potassium were used in the nutrient solution to determine their effect on growth, and also to estimate, by the Mitscherlich equation, the endogenous amount of a nutrient that participates in further growth.

Growth curves of the individual sections showed that elongation was most rapid in the fourth millimeter from the tip, followed in order by the third, fifth, second, sixth, and first millimeters.

The size, i.e., fresh weight, of individual cells increased 10 times from the first millimeter through the fifth; water increased 12 times, dry matter increased only 4

¹Doctoral thesis no. 1633, submitted January 28, 1955. Chairman of Committee, W. E. Loomis, Department of Botany and Plant Pathology.

²B.S., University of Miami, Coral Gables, Florida, 1949. M.Agr. Inter-American Institute of Agricultural Sciences, Costa Rica, 1951. Graduate Assistant.

times, and various cell constituents 2 to 8 times. There was thus a decrease in the concentration of all minerals due to increased hydration.

The order of importance of five macro-nutrients in the meristematic, first millimeter cells was nitrogen, phosphorus, potassium, magnesium, and calcium. The most marked change in the fifth millimeter was a relative increase of potassium and a shift in the nitrogen from 1/8 to 1/3 in a soluble form, and in the phosphorus from 1/4 to 1/2 in a soluble form. Calcium percentages were extremely low in all sections.

Growth of individual root sections in culture showed growth rates over a 24 hour period which were comparable in distribution but smaller than growth of the same zones in intact roots. Growth of root tip sections in a modified White's medium produced extensive and apparently normal growth for about 10 days, which then decreased, even though nutrient supplied appeared adequate.

An hypothesis to explain quantitatively the cause of varying rates of growth in the first six millimeters of the root tip states that an organism has an inherent power of growth which is modified by a growth factor, assumed to be an auxin-like substance found in supra-optimal, optimal, or limiting quantities.

$$\text{The equation,} \quad y = bx(X - x) \quad (1)$$

where (y) is the specific growth rate, (b) is the growth constant of the maize root tip and (X) the concentration of a growth factor which decreases with distance from the tip, is shown to describe the growth of 1-mm zones in the maize root tip.

A parabolic relationship was found between cell size and nutrient quantity;

$$W = kX^n \quad (2)$$

where (W) is the fresh weight of the cell, (X) the nutrient quantity and (n) a constant. Thus the cell weight and nutrient quantity are always related to each other by a constant quantitative factor (n).

An hypothesis showing the dependence of cell size upon the combined nutrients present is described by the equation,

$$W = k_b \sqrt[N]{x_1^{n_1} \cdot x_2^{n_2} \cdot \dots \cdot x_n^{n_n}} \quad (3)$$

where (N) is the number of nutrients associated with growth. This equation shows that cell size is quantitatively related to the combined nutrients in the cell.

Use of the Mitscherlich equation to analyze the results of the tissue culture experiment enabled an estimation of the endogenous nitrogen and phosphorus fractions in the apical section that participated in further growth. Seventy-three per cent of the nitrogen and 57 per cent of the phosphorus were found to be active in further growth.

SECONDARY STRESSES IN TRUSSES WITH RIGID JOINTS, SPECIAL APPLICATION TO GLUED WOODEN TRUSSES¹

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The main objective of this investigation was to determine the importance of secondary stresses in a truss with rigid joints, and what allowance should be made in the design of this type of truss. Incidental objectives were (1) to find methods of measuring strain in wood, (2) to determine properties of plywood suitable for this type of construction, (3) to select acceptable design values for wind pressures, and (4) to study methods of loading full scale trusses so that accurate loads could be applied and removed quickly over a wide range of values.

A 36' Fink truss was selected for study as it represented a type commonly used in the North Central Region for farm buildings, and one which could be easily fabricated with plywood gusset plates and glue.

¹Doctoral thesis no. 1594, submitted August 17, 1954. Chairmen of Committee, Henry Giese, Department of Agricultural Engineering, and R.A. Caughey, Department of Civil Engineering.

²B.S., South Dakota State College, Brookings, S.D., 1939. M.S. Michigan State College, East Lansing, Michigan, 1948.

A review of literature was made to determine suitable values for design for wind pressures. The following values were selected for the pressure coefficients to be applied to the basic wind pressure against a flat surface.

Upper 1/2 of leeward side of roof	-0.5
Lower 1/2 of leeward side of roof	-0.5
Lower 1/2 of windward side of roof	+0.3
Upper 1/2 of windward side of roof	-0.2

A theoretical analysis was made of the truss with two combinations of load and it was found that a snow load plus dead load loading caused the highest stress in the members. The wind loads reversed the direction; however, the magnitude of the stresses was lower. With the dead load plus snow load loading, the axial stress in all members was determined by graphics and the elongation of each member computed. A Williot diagram was used to determine panel point deflections. The algebraic sum of the deflections at each end perpendicular to the member was computed and the slope deflection formula used to determine the moment in the members.

After the moments were computed for each member a redistribution was made by the Moment Distribution procedure.

Under actual conditions the truss would be loaded over the entire length of the top chords which would also introduce additional moments. The loading apparatus used in this test applied equal loads at the third points of the top chords and at the panel points. This loading introduced moments approximately ten per cent less than if the same total load had been uniformly distributed. The fixed end moments were calculated for third point loading and redistributed among the members by Moment Distribution procedures.

In this investigation the stresses caused by axial forces and by bending in the top chords were considered as primary and the stresses caused by deflections were considered as secondary.

Preliminary tests were run (1) to determine the practicability of using SR-4 electric strain gauges on wood, (2) to investigate the possibility of using brittle lacquer to locate points of maximum strain, (3) to check the method of applying full load to a full scale truss, and (4) to determine the modulus of elasticity to be used in calculating the stresses from the measured strains.

The experimental trusses were constructed using 2" x 4" Douglas fir for the bottom chords and the web members and 2" x 8" Douglas fir for the top chords. Douglas fir plywood, grade AA exterior, 3/4" thick was used for the gusset plates which were glued with aircraft type casein glue. Pressure during the gluing process was provided with 8d nails spaced approximately 4" o.c., however, in the final truss the nails were removed before the experimental work was started. This method of construction is very quick and can be done with inexperienced help.

A preliminary truss was used to check the apparatus and the use of brittle lacquer in locating the areas of maximum strain. The truss was loaded while resting in a horizontal position. Loads were applied at the panel points and the third-points of the top chords by eleven hydraulic cylinders acting in tension along the bottom of the truss. Strap metal saddles connected the cylinders to the loading points.

When a load of approximately two and one-half times the design load was applied to truss number one, member L_1L_0 pulled loose at joint L_1 . Investigation showed that imperfect construction caused the failure. The unit stress on the glue area at the time of failure was computed to be eight times the allowable design value of 95 psi.

The final truss was placed in the testing frame and loaded to nearly two times the design load in increments of 133 pounds per loading point or 50 psi fluid pressure.

SR-4 strain gauges were used to measure unit strains on the four surfaces at the ends of each member. The measured axial strain was found by averaging these four values. The strain due to bending was computed as one-half the difference between the strain on the top surface and the bottom surface (when the truss is in a vertical position). The experimental values were compared with calculated values and the following conclusions drawn.

1. The SR-4 strain gauge is useful in determining quantitatively the strain in wood although tests are needed to determine accuracy and other characteristics. Brittle lacquer can be used to indicate the distribution of stress.
2. Stresses classed as secondary in this investigation were less than 17.6 per cent of the primary stresses. This can be allowed for in design if the members are designed as columns where appropriate reductions for the design unit stress are made. The high secondary stresses occur in each member where the effect of column action is least.

3. In the use of a design unit stress of 95 psi (recommended for shear in wood) for glue line shear, the factor of safety is from six to eight. In this case, therefore, both the glue and the wood in the plywood have a large factor of safety.
4. The use of hydraulic cylinders for loading a truss is probably the most accurate and the most practical method available. Small or large loads can be applied quickly and with equal accuracy.

POWER OF TEST PROCEDURES FOR CERTAIN
INCOMPLETELY SPECIFIED RANDOM AND MIXED MODELS¹

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In this study we consider the simplest case of pooling procedures for mean squares in an analysis of variance leading to the test of a hypothesis. The situation, which arises in different forms in various applications, may be generally described as follows: Given three mean squares, V_1 , V_2 , and V_3 based upon n_1 , n_2 , and n_3 degrees of freedom, respectively, it is desired to test a hypothesis involving V_3 . The proper test statistic to be used is known to be V_3/V_2 . However, it is suspected that V_1 has the same expectation as V_2 , in which case the proper statistic is V_3/V , where

$$V = \frac{n_1 V_1 + n_2 V_2}{n_1 + n_2}.$$

It is therefore decided first to perform a preliminary test of significance, using the statistic V_2/V_1 . If this turns out to be significant, V_2 is used as the error for the final F-test; if, however, the preliminary test is not significant, V is used as the error. The entire test procedure is usually referred to as the sometimes pool procedure.

The present study is concerned with the power of the sometimes pool procedure as applied primarily to component of variance models with the following properties:

- (i) The mean squares V_i ($i = 1, 2, 3$) are independently distributed as $\chi^2_i \sigma_i^2/n_i$, where χ^2_i is the (central) χ^2 statistic for n_i degrees of freedom.
- (ii) The main purpose of the analysis is to test the hypothesis $\sigma_3^2 = \sigma_2^2$ against the alternative $\sigma_3^2 > \sigma_2^2$.
- (iii) The error mean square V_2 has an expectation σ_2^2 , which is greater than or equal to the expectation, σ_1^2 , of the doubtful error mean square. This property follows from the analysis of variance models considered.

The test procedure is as follows: Reject the hypothesis if

either $\left\{ V_2/V_1 \geq F_{n_2, n_1}(\alpha_1) \text{ and } V_3/V_2 \geq F_{n_3, n_2}(\alpha_2) \right\}$

or $\left\{ V_2/V_1 < F_{n_2, n_1}(\alpha_1) \text{ and } V_3/V \geq F_{n_3, n_1+n_2}(\alpha_3) \right\},$

where $F_{n_i, n_j}(\alpha)$ is the 100 α per cent point of the F distribution with numerator degrees of freedom n_j .

Earlier results are extended to cover all of the important degrees of freedom combinations occurring in the analyses of variance under discussion. This extension is made possible by

- (i) the development of the power integrals as series formulas;
- (ii) the derivation of recurrence formulas for the power; and

¹Doctoral thesis no. 1673, submitted June 3, 1955. Chairman of Committee, T.A. Bancroft, Department of Statistics.

²B.S., University of Minnesota, Minneapolis, Minn., 1937. M.S., *ibid.*, 1938. Instructor, Statistics, Associate, Agricultural Experiment Station.

(iii) the development of approximate formulas valid for large degrees of freedom.

The power is an eight parameter function of $n_1, n_2, n_3, \alpha_1, \alpha_2, \alpha_3, \theta_{32} = \sigma_3^2/\sigma_2^2$ and $\theta_{21} = \sigma_2^2/\sigma_1^2$. Recommendations to the experimenter must be concerned primarily

with the choice of α_1 , the level of significance of the preliminary test. Numerical evaluation of the effect of varying α_1 (confined primarily to $\alpha_2 = \alpha_3 = .05$) was made in an attempt to formulate recommendations. These recommendations are based upon

- (i) the variation in the size of the corresponding test procedure as a function of θ_{21} , for fixed values of the remaining parameters; and
- (ii) a comparison of the power of the test procedure with that of the so-called never pool test ($\alpha_1 = 1$) of the same size.

In using the levels of $\alpha_2 = \alpha_3 = .05$, we stipulate an upper bound for the size to be not much greater than .10; then the following recommendations are proposed (these are contingent upon what may be regarded as a reasonable assumption concerning θ_{21}):

- (i) If it is reasonably certain that only small values of θ_{21} (θ_{21} between 1 and 1.5 to 2) can be envisaged as a possibility, $\alpha_1 = .25$ is recommended, except that for $n_3 \geq n_2$ and $n_2 \geq 5n_1$, $\alpha_1 = .50$ is recommended.
- (ii) If no such assumption can be made concerning θ_{21} , and the possibility of power losses is to be avoided, the never pool test or the borderline test (defined on page 26 of the thesis*) is recommended.

*Two copies of the complete thesis are on file at the Iowa State College Library, Ames.

AN ANALYSIS OF SOME TWO-WAY STRATIFICATIONS¹

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With stratification the population to be sampled is divided into groups or "strata" so constructed that units in the same stratum are "more alike" than units in different strata. Sometimes two criteria are used for stratifying the population. Thus, farms may be subdivided by economic areas and by acreage groups, or households may be divided by geographic regions as well as by rural, urban, and metropolitan areas. In such cases one may speak of a two-way table of strata "cells." A cell in the first of the above examples would consist of all farms of a particular acreage bracket in a particular economic area.

If the sample to be drawn from a two-way stratified population is large enough to permit the allocation of at least two units to each of the cells, a two-way table of strata cells clearly can be dealt with by the ordinary methods of stratification, and no new problem arises. That is, if the two-way classification has L rows and M columns the LM cells can be considered as LM strata and the usual formulas for estimators and variances apply. At least two sample units must be assigned to each cell if an unbiased estimate of the variance is required.

Problems may arise, however, when the size of the sample, n, is less than twice the total number of cells, and certainly will arise when it is less even than the total cells, LM.

The purpose of this study is to examine the characteristics of a particular two-way stratification design which, for samples less than 2 LM, permits estimates to be made of row, column, and population means, and, further, provides essentially unbiased estimates of the variance of the estimated population mean. The only restrictions on sample size are that, for estimates of means, the sample must be at least as large as

¹Doctoral thesis no. 1659, submitted May 26, 1955. Chairman of Committee, R.J. Jensen, Department of Statistics.

²B.S., University of Wyoming, Laramie, Wyo., 1938. M.S., *ibid.*, 1940.

the larger of L or M, and, for estimates of variances, the sample must be at least as large as $2(L + M)$.

It will be shown that our method of two-way stratification is particularly effective if the population cell frequencies are proportional to both marginal frequencies, that is, if the two criteria of classification are independent in the statistical sense. In this case two-way stratification will practically always be more precise than simple stratification using either of the two criteria for constructing the single system of strata. In fact, the variance with either single stratification will always be larger than $(n-1)/n$ times the variance with our double stratification, so that the maximum loss in variance that may result with two-way stratification under proportionality of frequencies is $100/(n-1)$ per cent of the single stratification variance.

Both a biased and an unbiased estimator for the two-way stratification design have been considered. When the cell frequencies are proportional to marginal frequencies, the two estimators are identical and the "biased" estimator is, in fact, unbiased. The unbiased estimator and its variance require knowledge of the proportion of the population in each cell, but the biased estimator and its variance require only knowledge of the marginal strata proportions. This important fact permits application of the two-way design to populations in which the marginal proportions of units in each class of the two stratifying criteria are known, but not the proportions in each cell of the two-way table.

If cell frequencies are not proportional to marginal frequencies, situations may arise in which two-way stratification gives less precise results than one-way stratification. Such situations arise when the characteristic of the population being studied has a strong "interaction" in comparison with the "row" and "column" effects in the usual analysis of variance sense, where the "rows" and "columns" are identified with the marginal stratifications in the two-way table.

In the above discussion it has been assumed that every cell of the two-way table contains some units of the population. If there are some empty cells, special techniques are required for obtaining estimates of row, column, and population means. Some attention is given to this problem and solutions are given for the common cases likely to be met with in practice.

RIDGE FARMING AND PLANT ROOT ENVIRONMENT¹

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This study developed the machinery, tillage and cultural practices used for the ridge-farming system proposed in 1951 by Professor E. V. Collins, Agricultural Engineering Department, Iowa State College.

The primary objective was the development of a system of land management which did not sacrifice crop production while conserving soil, water, and nutrients.

The ridge-farming system was compared with conventional, Ohio, and furrow (listed) systems of farming in the primary tillage experiment. The ridge maker, two-way plow, disk-bedder, mounted planter, and disk-hiller were constructed and developed to perform the necessary field operations. The above machines, with the exception of the ridge maker, were successfully used during the 1953 and 1954 crop years.

Measurement data concerning the physical nature of the environment of the roots were recorded throughout the growing season.

Soil temperatures were measured with laboratory thermometers in the primary tillage experiment. The ridges were found to be warmer than the furrows. After the first cultivation on June 16, 1953, no real difference in temperature was recorded from the various tillage treatments. Additional readings made on July 2, 1954, show that the ridge temperature was only slightly higher than that of the conventional farmed plots.

¹Doctoral thesis no. 1595, submitted August 20, 1954. Chairmen of Committee, E. V. Collins, Department of Agricultural Engineering, and Don Kirkham, Department of Agronomy.

²B.S., Kansas State College, Manhattan, Kans., 1943. M.S., University of Arkansas, Fayetteville, Ark., 1951. Instructor, Agricultural Engineering.

The moisture content and bulk density profiles of the above experiment were determined for the 1953 crop year. No real difference was found in the moisture content due to tillage, but the differences in bulk density between the systems were found to be significant.

The above ground storage capacity and velocity of water flowing in the furrows were analyzed. The reduction of infiltration capacity of a ridged field was studied from the standpoint of furrow compaction and reduced wetted perimeter. In the laboratory a glass-faced soil lysimeter was used to follow the progress of the wetted front. In the field the state of soil structure was determined by bulk density and penetrometer measurements. Photographs recorded the different rates of infiltration of the traveled and untraveled furrows.

An analysis of the above data shows that the travel of the tractor wheels compacted the soil and reduced the infiltration capacity of the furrows.

The effect of raindrop erosion was observed and analyzed. It was found to reduce the height of the ridge and to provide some measure of weed control.

The weight and height of cornstalks and the development of the root system between ridge and conventional farmed corn was compared and found to be in favor of the ridge-farmed corn.

The planting of high moisture content seeds to produce a rapid rate of germination and emergence was studied and found to be feasible.

The chemical environmental study showed to be true, one or both of the following: That the rate of nitrification was greater in the ridge than in flat-farmed land or that the rainwater did not leach the nitrogen that was made available.

Comparable corn yields were harvested from the ridged and conventional-farmed plots. The ridge-farmed corn, however, produced a significantly higher yield than any other soil conserving farming system tested.

The rotation of corn-corn-oats-meadow was found to be adaptable to this system of farming.

A warm, well-drained seedbed with good structural properties was produced by the ridge-farming system. This seedbed was economically developed with available commercial machinery.

GENETIC AND ENVIRONMENTAL VARIANCES IN SEGREGATING AND NON-SEGREGATING MAIZE POPULATIONS¹

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Department of Agronomy

Various mathematical models have been devised for the estimation of genetic parameters in plants and animals. Their utility in the interpretation and understanding of the mechanism of quantitative variability is dependent upon the validity of their specific application. All such models are necessarily limited by certain basic assumptions characteristic of the particular model. If these basic assumptions are not realized, then the value of the estimates may be extremely limited. The investigations reported herein were undertaken primarily to provide information on the validity of the model, $V_G = V_{F_2} - V_E$, where V_E is the environmental variance estimated from the non-segregating populations (P_1, P_2 , and F_1), V_{F_2} is the phenotypic variance of the F_2 population, and V_G is the genotypic variance of the F_2 . This model assumes that the effect of the environment is the same for all genotypes, and that genic effects are additive over loci. The suggested procedure for satisfying the assumption of equal environmental effects for all genotypes is to make use of a scale on which the non-segregating populations have equal variances within the limits of sampling error. The assumption in using the resulting scale for the segregating population is that all genotypes will have a constant effect for environment on the same scale.

Individual plant data were collected on six inbred lines of corn, their 15 single

¹Doctoral thesis no. 1661, submitted May 27, 1955. Chairmen of committee, G.F. Sprague and I.J. Johnson, Department of Agronomy.

²B.S. North Carolina State College, Raleigh, N.C., 1949. M.S. Ibid., 1952. Graduate Assistant.

crosses (F_1 's), 15 F_2 's, and 30 backcrosses. The material was grown in a randomized block experiment at two locations and in two years. The attributes measured in this study were plant height, kernel row number, length of ear, diameter of ear, weight of 100 kernels and weight of shelled corn. Kernel row number exhibited the least and weight of shelled corn the maximum degree of heterosis. Kernel row number, length of ear, diameter of ear, and weight of 100 kernels are considered as components of yield. Heterosis of the F_1 was calculated for each character as the per cent of the top parent.

Within-plot variances were calculated for each non-segregating population and were tested for homogeneity of variance by Bartlett's test. The variances were generally found to be heterogeneous for the attributes showing the greatest degree of heterosis. Heterogeneity was found among the F_1 and parental variances as well as between the two groups. For a particular genotype the variances were generally different for different years or different locations.

Since the variances were heterogeneous, the possibility of a linear relationship between the means and variances was investigated by correlations. The absence of any general relationship indicated that the use of a simple transformation of the data would not make the variances homogeneous. When examined on a cross basis the variances generally were not alike for P_1 , P_2 , and F_1 . In most cases, there was no linear relationship for means and variances when examined on a cross basis.

Genotypic variances and heritabilities were calculated for the F_2 populations by two methods; differing in the procedure used for estimating the environmental portion of the variance. The within-plot variance of the F_1 was compared with the average of the parental and F_1 within-plot variances as they affect the consistency of the resulting estimates of heritability for the F_2 populations. The inconsistency of the estimates for the same cross when grown in different locations or years was apparent for each method. It was seen that the size of estimates was related to the method of estimating the environmental variance, the genetic material used, and the year or location in which the material was grown.

The additive genetic variance and its proportion of the phenotypic variance of the F_2 population were estimated by the use of the F_2 and two backcross populations. The estimates were very erratic, and the method appeared to be of little value with this material.

Scaling tests were made for nonadditive gene effects among loci by the relationships given by Mather. Many instances were found where the observed scale would be termed inadequate. However, when this scaling test was considered along with the test for heterogeneous variances, the two were not always in agreement. A change of scale to satisfy one criterion may adversely affect the other.

WIND RESISTANT CHARACTERISTICS OF AND A STANDARD RATING PROCEDURE FOR ASPHALT SHINGLES¹

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The enormous losses resulting from windstorm damage to asphalt shingles on Iowa buildings were causing considerable concern prior to 1951 and demonstrated a need for an investigation concerning the wind resistance characteristics of this type of roofing, which had proven to be an economical and otherwise acceptable material. Therefore, this study was proposed as a continuation of an Iowa Agricultural Experiment Station general project, "An Investigation of Farm Building Losses Due to Wind and Fire," which had been in progress since 1930.

Since this investigation was restricted to tab type asphalt shingles, a first consideration involved the wind reaction on a tab, or tabs. A full size scale tab model, so mounted that the force of the wind could be measured and placed on a roof section

¹Doctoral thesis no. 1619, submitted December 9, 1954. Chairmen of committee, Henry Giese, Department of Agricultural Engineering, and R.A. Caughy, Department of Civil Engineering.

²B.Sc., Virginia Polytechnic Institute, Blacksburg, Va., 1951. M.S., *ibid.*, 1953.

model in front of a wind duct supplied by a gasoline engine operated fan with a capacity to produce up to a 50 miles per hour wind, demonstrated that the lifting force pattern of the wind was a minimum when the shingle tab was flat on the roof deck; that it increased to a maximum several times greater with the tab at an angle of 20° , plus or minus 5° depending on air turbulence, direction and velocity; and then decreased as the tab angle was increased to a 90° angle with the deck, at which point the decrease amounted to as much as 30 per cent under certain conditions. When an adjacent tab on each side of the model was lifted, the maximum force occurred at a smaller tab angle and a greater decrease in force at the larger angle resulted.

Observations relative to the effect of the size and shape of the tab illustrated that the effective wind force on a four-inch exposure tab was on the order of 60 per cent of that on a five-inch exposure tab and the net effect on a hex-tab was less than 50 per cent of the latter. Percentages varied with wind velocities.

In order to provide a means of testing the bending characteristics of asphalt shingles and of rating commercial shingles, a bending machine was developed which operated on the following principle: A three-tab strip was applied to a decking, either with roofing nails or a special fastening device with simulated nails, with the tabs extending over the edge of the deck so that a lift bar could raise them through the desired angle. The lifting force was provided by selected weights, one producing an initial and constant moment and the other providing for an increasing moment to simulate the increasing force of the wind during the initial angle of lift and then to provide a further increase to simulate the additional force created by gusts or increasing velocities. Recording devices were incorporated to record mechanically the angle of lift and the number of bends to which the tabs were subjected. Also included were adjustments to provide for a flipping action of the tabs at desired angles of lift and for selected speeds of operation. The moment producing weights provided the simulated wind force on tabs and an electric motor provided power for the operation of the return mechanism and angle recording table. The operation of this bending machine was quite satisfactory and it offers excellent possibilities for future rating operations, if such are deemed expedient.

The investigation of a shingle's resistance to bending was considered with regard to its capacity to resist being bent and to its flexibility, or tolerance to repeated bending without damage. Nineteen square-tab type asphalt shingles, including thick-butt, tapered, and uniform thickness types, and seven hex-tab types, products of fourteen manufacturers and purchased from Iowa retail sources, were considered in this investigation. Composition analyses of these shingles made by Professor M. L. Esmay, formerly a member of the Iowa State College Agricultural Engineering Department, were available and included the following characteristics: (1) weight of dry felt, (2) amount of felt saturation, (3) amount of top coating bitumen, (4) amount of back coating bitumen, (5) per cent of filler in coating, (6) amount of top surface granules, and (7) amount of back dusting mineral.

The flexibility and resistance operations were conducted simultaneously and involved the tabs being initially lifted through an angle of approximately 15° to 20° , this being the range of maximum force for a given wind velocity. Successive applications of the lifting forces raised the tabs through a 90° angle. Subsequent to each force application the tabs were allowed to return freely toward the zero position at a speed controlled by the shingle's properties. These properties generally caused a tab to return rapidly through approximately one-half the angle through which it had been raised; after which it quickly reduced its return speed and continued slowly toward its original position. The time periods between successive applications of the increasing magnitude lifting forces were adequate to permit the tabs to reach the slow rate of descent. Although a wind of sufficiently high velocity could be expected to lift the tabs through a much greater initial angle, this procedure was considered to be the result of a much more common condition resulting from lower velocity wind with varying velocities or gusts. After being raised through a 90° angle the tabs then were subjected to a flipping action through a small angle.

Tests were conducted at 50° , 70° , and 85° F temperatures with flexibility results indicating that asphalt shingles as manufactured today do not have adequate characteristics to permit anticipated bending when tabs are lifted by the wind. In addition, bending prior to failures weakens a shingle and thus makes it more susceptible to being lifted again and to being torn off.

Although performance was better at higher temperatures, those used were considered as incorporating a logical temperature range, and satisfactory performance can be evaluated only by considering reactions over the entire range. The shingle failures

included bitumen cracks, first occurring below the nails and then continuously across the tabs, felt breaks primarily below nails, and, more common at low temperatures, tearing of the sides of the cutouts between tabs, and combinations of these defects. Neither failure nor better performance was confined to similar composition characteristics, and both occurred on shingles randomly located throughout the range of component part weights and thickness and with embossed, plain, thick-butt, and uniform thickness types.

A circular shape for the top of the cutout appeared to be advantageous, since sharp angular intersections between tab and shingle body, with resulting stress concentrations, were failure points on each shingle strip at 50° and 70° temperatures and few curved shapes failed. Embossing also provided for earlier failures when the indentation line was collinear with the bending line or when it intersected the top of the cutout.

Inasmuch as these failures occurred prior to the end of 100 flips executed after repeated force applications to lift the tabs through a 90° angle, which averaged only 51 applications per shingle, the reactions produced were less severe than those to be expected from strong winds. Therefore, flexibility characteristics are inadequate, the character of a shingle ingredient does not have the necessary elasticity, and longer life performance depends on a shingle's resistance to being lifted by the wind.

A shingle's resistance to being raised by the wind was considered with respect to the initial angle of maximum wind force and to its being raised to 30° and 90° angles, respectively. Analyses of these results with the quantitative composition characteristics and with the ratios of the various component parts revealed very little correlation for better performance and indicated a need for a higher resistance quality in the materials. This involves important economic considerations, implying stronger felts and less compressible top bitumen, with partial compensations resulting from greater thicknesses of both.

The top bitumen content provided the most acceptable criterion for the quantitative composition analysis, with low values for this material resulting in less resistant shingles. Since an asphalt shingle bends about a neutral axis near the top of the felt and the compressive stresses are a function of the thickness, this is a logical result. Bitumen below the felt, usually in small proportions and because of low tensile strength, provided little net effect on resistance.

The filler content was demonstrated to be an inadequate factor in determining resistance, if not included in excessive quantities. Shingles with filler to bitumen ratios between 0.60 and 0.85 were well scattered throughout the resistance range. Also included were three zero filler content shingles, two with low resistances and one with a high resistance.

Other interesting observations demonstrated a low initial resistance and considerable variation in the resistance of different shingles of the same type when subjected to repeated bending. This low resistance of asphalt shingle tabs during the first few degrees (3-5) of lift readily permits them to be exposed to one-third or more of the total wind force. The variation indicated by the results, wherein one shingle in each group of three samples often was considerably more or less resistant than the other two, illustrated probable manufacturing deficiencies in quality control and a need for a large number of samples when investigating asphalt shingle resistance.

INOSITOL HEXAPHOSPHATE IN SOILS¹A. GEORGE CALDWELL²

Department of Agronomy

An investigation was made of the phosphorus present in soils as inositol hexaphosphate. A method was developed for the quantitative determination of two components of soil organic phosphorus. The method involved differential elution of the compounds by dilute hydrochloric acid from a bed of the weak-base anion exchange resin De-Acidite. A partially purified preparation of soil organic phosphorus was adsorbed on a column of the resin and eluted with 500 ml of 0.85 N hydrochloric acid. Subsequent elution of the column with 250 ml of 1.40 N hydrochloric acid removed one of these components. Further elution with 250 ml of 3 N hydrochloric acid removed another component of soil organic phosphorus.

The first component was identified as an inositol hexaphosphate on the basis of quantitative measurements of inositol and phosphorus. Qualitative testing with a mutant of *Neurospora crassa* indicated that the inositol was probably present as the meso isomer. The other component was less accurately identified. On the basis of positive qualitative chemical tests for inositol and the adsorption characteristics of the compounds, it was suspected to be an isomer of inositol hexaphosphate.

The two inositol hexaphosphates made up an average of 16 per cent of the organic phosphorus fraction in samples of 49 surface soils collected from various locations in the United States and Canada. The total content of phosphorus as inositol hexaphosphate ranged from 5 ppm to 98 ppm. About two-thirds of the total was meso-inositol hexaphosphate, and one-third was the supposed isomer of inositol hexaphosphate.

The content of inositol hexaphosphate increased with increasing content of organic phosphorus in other forms. The regression of inositol hexaphosphate content on the content of other forms of organic phosphorus, independent of soil pH and free iron oxide content, was significant at the 1 per cent level. The content of inositol hexaphosphate was not significantly associated with soil pH and free iron oxide content independently of the content of other forms of organic phosphorus. The statistical relationships are shown in Equations 1 and 2. Equation 1 shows the multiple factor relationships. Equation 2 shows the simple regression of inositol hexaphosphate on content of organic phosphorus in other forms calculated after elimination of the nonsignificant independent variables.

$$1. \quad p_i = -6.13 \text{ pH} - 0.231 \text{ Fe} + 0.117 p_o + 53$$

$$\quad \quad \quad \pm 3.51 \quad \quad \pm 0.130 \quad \quad \pm 0.025$$

$$2. \quad p_i = 0.126 p_o + 13.6$$

$$\quad \quad \quad \pm 0.026$$

The standard errors associated with the regression coefficients are located directly below the respective coefficients. In these equations, p_i = ppm of phosphorus as inositol hexaphosphate, Fe = parts per thousand of iron as free iron oxide and p_o = ppm of organic phosphorus in forms other than inositol hexaphosphate.

The content of both inositol hexaphosphate and other forms of organic phosphorus was found to be less in samples from ten cultivated sites than in samples from the comparable virgin sites. The ratio of inositol hexaphosphate to other forms of organic phosphorus did not differ significantly between virgin and cultivated sites, however, which indicates that during cultivation the organic phosphorus in both categories had decomposed at about the same relative rate.

Organic phosphorus of microbial origin was accumulated in subsoils, clays, and sand by incubating these materials after inoculation with soil microorganisms and addition of inorganic nutrients and carbohydrates. No inositol hexaphosphates were detected in the original materials. After incubation, however, measurable amounts of meso-inositol hexaphosphate and the supposed isomer of inositol hexaphosphate were found by the chromatographic method. From this evidence of microbial synthesis of

¹Doctoral thesis no. 1670, submitted June 3, 1955. Chairman of committee, C.A. Black, Department of Agronomy.

²B.S.A., University of Toronto, Toronto, Canada, 1946. M.S.A., *ibid.*, 1948. Graduate Assistant.

both meso-inositol hexaphosphate and the supposed isomer of inositol hexaphosphate, it appears that part of the inositol hexaphosphate in soils is microbially derived.

The value of approximately 2 for the ration of the phosphorus present as meso-inositol hexaphosphate to that present as the supposed isomer in soil organic phosphorus is rather different from the ratio of approximately 0.5 for the same substances in microbial organic phosphorus accumulated in the different inorganic materials. Since meso-inositol hexaphosphate is found in plants and the supposed isomer apparently is not, it may be speculated that most of the phosphorus present in soils as meso-inositol hexaphosphate is residual from plants. Some of the meso-inositol hexaphosphate and all the supposed isomer of inositol hexaphosphate are presumably of microbial origin.

OVIPOSITION RATES AND YIELD IN *APIS MELLIFERA* L.¹

GLADSTONE HUME CALE²

Department of Genetics

This study considered two main points: the determination of effective oviposition rates of certain inbred lines of honey bees and their F_1 progeny, and the determination of honey yield from progeny of random mated inbred females and progeny of random mated F_1 females. Of particular interest was the problem of heterosis in the F_1 crosses and the implications to bee breeding should heterosis be demonstrated.

There are two generations in the honey bee colony--the queen mother, and her worker progeny. Maximum usage of hybrid vigor in this species would, therefore, depend upon the demonstration of this phenomenon in both the queen bee and her worker progeny. For this study, hybrid vigor was regarded as the superiority of the hybrid over the better parent.

The genetic material was composed of four inbred lines of honey bees formed by instrumental insemination using parent-offspring and sister-sister matings. In addition to the inbred lines, their six single-cross F_1 's and a representative random-breeding stock were also included. The range of inbreeding for the inbred material used in this study was from 56.7 to 65.8 per cent. The eleven groups studied were placed in six replicated apiaries, each apiary containing 47 colonies of honey bees.

Oviposition rate for all groups was determined as an average egg-per-day count covering a 12-day period preceding the honey flow by 10-22 days. Total honey yield for each individual colony was determined at the end of the honey flow period.

Contributing sources of variation were examined and tested. For the hybrid groups, this included an analysis of the contributions of general and specific combining abilities.

The performance of inbred lines of honey bees was shown to be a poor indication of their value in cross combinations. Original selections of material for inbreeding purposes were shown to have little value for oviposition rate, and to be more consistent for honey yield.

Heterotic effects were demonstrated for both oviposition rate and honey yield. These effects were such that five of the six F_1 's exceeded their higher parent in oviposition rate, and four of the random mated F_1 's exceeded their higher parent for honey yield. Expressed as a percentage of the higher parent, the egg productivities of the F_1 honey bee queens ranged from 105 per cent to 166 per cent, with an average productivity increase of 35.5 per cent. F_1 honey yield productivities ranged from 96 per cent to 129 per cent, with an average yield increase over the higher inbred parent of 14.7 per cent.

Inbred lines in this genetic study were shown to exhibit differences in both general and specific combining ability. In the yield data, four of the six F_1 's showed increases over their higher parent. In all cases, these F_1 's involved one or both of the two inbred lines with the best general combining ability for high yield. The two inbred lines with the poorest general combining ability for high yield gave the poorest F_1 , yielding only 96 per cent of its higher parent. Three of the highest oviposition rate increases

¹Doctoral thesis no. 1658, submitted May 25, 1955. Chairman of committee, John W. Gowen, Department of Genetics.

²B.A., Carthage College, Carthage, Illinois, 1941. M.S., Iowa State College, Ames, Iowa, 1952.

were found in the F_1 's having the best inbred for general combining ability for high egg laying. The poorest F_1 for oviposition rate was formed from the two inbreds showing the poorest general combining ability for high oviposition rate. It would appear that gene action resulting in general combining ability was more important to honey yield and oviposition rate in these data than was gene action resulting in specific combining ability.

The value of heterotic effects in a bee breeding program depends upon the demonstration that hybrids may be formed having greater productivity than the normally-available honey bees. F_1 performances were compared with the productivity of the random check stock. The oviposition rate of the average of the hybrids was 107.2 per cent of the random stock. The two better hybrids exhibited productivities of 114.4 and 116.7 per cent of the random stock. Expressed in terms of the random stock, the average honey yield of the hybrids was 106.2 per cent. The better yielding hybrid produced at the rate of 123.7 per cent of the random stock. These performances speak well for the future possibility of increasing honey bee productivities by the use of a hybrid breeding program.

SOCIOLOGICAL ANALYSIS OF PARTICIPATIVE EXPERIENCES
RELATING TO ADJUSTMENT OF INSTITUTIONALIZED
MENTAL DEFECTIVES AND EPILEPTICS¹

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Department of Economics and Sociology

Patients admitted to an institution for mental defectives and epileptics, having been uprooted from their home community and placed in an entirely new social milieu, are confronted with the task of adjusting to the new environment. Upon admission, they are of varying ages, mental levels, and physical conditions. They have had different home backgrounds, school experiences, and community relationships. Yet each patient is required to adapt himself, to a greater or lesser degree, to the institutional power system and to individuals within the system. Throughout their stay in the institution, patients participate in various activities which play their part in modifying behavior and affecting their adjustment to the institution.

Heretofore, the determination of which participative experiences have a definite relationship to adjustment has been made primarily on a conjectural basis. Although the staff of the Woodward State Hospital feels its training program compares favorably with those of other institutions, it recognizes that the relative influence of these group experiences and early background experiences on patient adjustment has not been determined.

The primary purpose of this study was to determine if participative experiences and pre-institutional experiences relating to patient adjustment could be determined by objective methods. A secondary objective was to determine if participative achievement in selected areas of hospital activities could be prognosticated from data regarding pre-institutional experiences.

The areas of participation analyzed in this study were selected by the hospital professional staff as the primary influences affecting total patient adjustment. Adjustment was analyzed in relation to participative achievement in patient-peer relations, patient-staff relations, school, vocational training, recreation, and religious training.

Adjustment of 259 high grade defectives and epileptics was studied. The group consisted of 75 female defectives, 42 female epileptics, 91 male defectives, and 51 male epileptics. All patients had I.Q.'s higher than 50, were between the ages of 10 and 44, and had been in residence from 1 to 19 years.

A pragmatic view of adjustment was taken whereby individual staff members evaluated adjustment in accordance with their own definitions. Adjustment evaluations were made by the patient's ward doctor, ward attendant, work supervisor, teacher, and the male or female supervisor.

¹Doctoral thesis no. 1678, submitted June 4, 1955. Chairman of committee, Ray E. Wakeley, Department of Economics and Sociology.

²B.S., Southern Illinois University, Carbondale, Ill. M.S., *ibid.*, 1948.

Each patient was compared with other patients in the group in which he lived, worked, and played. His adjustment was rated on a five-point scale.

Primarily because of lack of objective data, ratings of achievement in each area of group life were obtained from staff members specifically acquainted with behavior in that area. Patients were rated on a five-point scale which included statements of the criteria for achievement at each level.

Data regarding pre-institutional experiences were taken from each patient's personnel folder. Each such experience was assigned a weight in accordance with the professional staff's estimate of its relative influence on participative achievement. These values were combined to form a prognostic evaluation of the individual's achievement potential in each area of group life.

The relationships between scores obtained on achievement prognosis, participative achievement, and adjustment were analyzed by analysis of variance, tests of *t*, and analysis of covariance.

Epileptics were found to have a mean I.Q. nine points higher than the mental defectives. They received significantly higher achievement prognosis scores but lower achievement scores than did defectives. There were no adjustment differences between the two groups. There were no sex differences in any of the analyses.

Participative achievement in each of the six selected areas was found to be significantly related to adjustment. Although achievement prognosis scores in four of the six areas of group life were significantly related to adjustment, none of them were able to estimate adjustment more accurately than were the mean achievement scores. The significant participative areas were, in order of significance, vocational training, patient-staff relations, recreation, and patient-peer relations. Finally, it was determined that participative achievement in patient-peer relations, school, recreation, and patient-staff relations could be prognosticated from the weighted scores obtained from data regarding pre-institutional experiences..

A STUDY OF THE OCCURRENCE OF TERATOGENY IN VITAMIN E-DEFICIENT RATS AND ASSOCIATED ABNORMALITIES IN BLOOD AND TISSUES¹

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Department of Animal Husbandry

The usual reproductive abnormality ascribed to vitamin E deficiency in female rats is fetal resorption. The purpose of this study was to demonstrate that congenital abnormalities could be produced under certain conditions of maternal vitamin E deficiency and subsequent gestational therapy.

For this study 763 rats of the Sprague-Dawley strain were used. After attaining 35 to 40 grams body weight each rat was weaned and randomly put on one of the four experimental rations used, namely, stock colony ration, basal vitamin E-depleting ration, basal ration to which was added a low level of tri-o-cresyl phosphate (25 µg/gm ration), and basal ration to which was added a higher level of tri-o-cresyl phosphate (100 µg/gm ration). The rats were mated with proven males from the stock colony when weighing approximately 175 grams. After positive mating was ascertained by vaginal smear, each rat was allocated randomly to one of the 36 groups on different dietary regimes. Erythrocyte sign in vaginal smears was employed to determine positive conception. Vitamin E therapy was instituted on certain days of gestation. On the 21st day of gestation each female was laparotomized and her uterine contents were examined, weighed, and preserved for macroscopic and histologic examinations. Blood from the umbilical cord of live fetus was used for hemoglobin determination, red and white blood cell counts, and differential counts.

The experiments demonstrated that when tocopherol therapy was given on the 9th, 10th, or 11th day of gestation, young with single or multiple abnormalities occur in the

¹Doctoral thesis no. 1577, submitted July 15, 1954. Chairman of committee, B. H. Thomas, Department of Animal Husbandry.

²B.S., Yenching University, China, 1936. M.S. Mount Holyoke College, South Hadley, Mass., 1948.

uteri either with or without the simultaneous occurrence of normal-appearing litter-mates. This phenomenon was observed in a total of 126 pregnancies. The incidence ranged from 45 to 75 per cent depending on the dietary regimes. The peak of incidence occurred when tocopherol therapy was given on the 10th day of gestation. This peak was not shifted by increasing the therapeutic level of tocopherol from 1 to 4 mg.

Abnormal feti were observed as early as the 15th day of gestation. The macroscopic abnormalities of all the full-term deformed feti in the order of descending incidence fell into the following categories: umbilical hernia, hydrocephalus, exencephalus, rigid ankle, receding mandible and maxillae, hare lip, cleft palate, ectocardia, kinked tail, syndactylism, taillessness, edema, protruding mandible, and "elephant trunk" nose. Also, the data demonstrated that hydrocephalus, umbilical hernia, and exencephalus occurred most frequently when tocopherol supplementation was given on the 9th, 10th, or 11th day of gestation respectively.

Histologic studies of the abnormal feti revealed marked retardation in development of heart, lung, and kidneys and a less marked arrest in development of practically all other organs and tissues. The thickness of the cerebral cortex of the normal-appearing fetus was reduced, while the lateral ventricles were larger than normal. In exencephalus the brain was disorganized and displaced. The eyes of the abnormal feti were either missing, small and lacking in differentiation, or subnormal in size. The striations of the skeletal muscles were indistinct or faint. The cardiac muscles were irregularly arranged with striations apparent in some and indistinct in others. The lungs were not fully expanded. The liver of some abnormal feti showed central hemorrhage and necrosis while the kidneys showed enlarged sinusoid with retarded development of the glomeruli, convoluted and collecting tubules.

Some of the skeletal malformations observed from cleared specimens of abnormal feti were complete or partial absence of certain cranial bones, retarded ossification of the sternebrae and phalangeal bones, curvatures of the vertebral column and fusion of certain ribs. Hematologically, the abnormal feti were very anemic with significant leukocytosis, monocytosis, eosinopenia, basopenia, and slight lymphocytosis. Other abnormalities observed were, 1) shorter crown-rump length, and, 2) lighter organ weights for the abnormal feti.

In short, abnormal feti showing a multiplicity of abnormalities macroscopically, microscopically, and hematologically were produced systematically for the first time by subjecting vitamin E-deficient female rats to d, l- α -tocopherol therapy during a critical stage in the development of the fetus.

THE APPARENT ADSORPTION OF SOME ALIPHATIC COMPOUNDS FROM AQUEOUS SOLUTIONS AS INFERRED FROM HYDROGEN OVERVOLTAGE MEASUREMENTS¹

BERT HOWARD CLAMPITT²
Department of Chemistry

A review of the literature indicated that adsorption results on metal surfaces are very scarce and that a rapid method of obtaining such results was not available. In view of this, the primary aim of this research was to develop a suitable method for obtaining adsorption isotherms on small metal surfaces.

In principle, two independent methods are set forth for obtaining adsorption data on metal surfaces; however, both methods are dependent upon the hydrogen overvoltage phenomena. The first method depends upon the steady state current-overvoltage relationship; while in the second method the double layer capacity of the metal-solution interface is measured.

Apparent isotherms for the adsorption of a number of organic compounds from aqueous solutions by silver and copper have been measured by double layer capacitance and steady state current-overvoltage techniques. The adsorption results obtained by

¹Doctoral thesis no. 1597, submitted September 9, 1954. Chairman of committee, R.S. Hansen, Department of Chemistry.

²B.S., Oklahoma University, Norman, Okla., 1950. Research Assistant, Institute for Atomic Research.

the two methods on silver, with the exception of n-heptaldehyde, agree within the limits of reproducibility. The results for copper indicate that although the limiting coverage is the same for the two methods, the shapes of the adsorption isotherms appear to differ significantly.

All of the results appear to be reasonable in order of magnitude; however, two points cause some concern. First, in no fatty acid-water system was an apparent coverage greater than 50 per cent observed. Secondly, the marked progression, n-heptaldehyde > heptanol-1 > n-heptylic acid, is in contrast to results for the adsorption of these compounds by carbon. Three possible interpretations of these facts are presented.

The application of the methods to highly soluble adsorbates is complicated by the alteration of the dielectric properties of the solution. In this case, care must be taken to correct for changes in reversible cell potential. With slightly soluble adsorbates the dielectric properties of the solution are not appreciably altered, and the method can be more simply applied.

INTERSPECIFIC AND INTERGENERIC HYBRIDS OF TRITICUM AND RELATED GENERA¹

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Department of Agronomy

The Red Winter variety of Triticum spelta and a synthetic allohexaploid of T. spelta, T. dicoccum x Aegilops squarrosa, were crossed with (T. dicoides x Ae. speltoides)⁶ⁿ x T. aestivum (var. Austin)⁴. This Ae. speltoides derivative was resistant to all known races of stem rust. The inheritance of reaction to race 15B of stem rust was studied in the greenhouse. The F₁ plants in the greenhouse were moderately susceptible to race 15B, but those in the field were resistant to all races present. The F₂ plants in the greenhouse from each cross segregated in an approximate ratio of nine susceptible to seven resistant plants. However, the probability from chi-square for the pooled data was between .02 and .01.

In one planting all seedlings of the resistant parent and the segregating progenies were completely susceptible. A majority of the F₂ plants in the field from the T. spelta cross were resistant to all races of stem rust, including 15B. Approximately five per cent of all F₂ plants were nullisomics. These plants segregated in a ratio of nine susceptible to seven resistant plants. The Ae. speltoides type of resistance to race 15B may be present in some varieties of T. aestivum because the gene or genes which determined this resistance were located on chromosomes that paired with those in the hexaploid wheat species. It was concluded that the inheritance or reaction in the seedling stage was different from that of the mature plant stage, and that the environment in the greenhouse influenced rust reaction.

The resistant parent has a close linkage between an undesirable type of spike and resistance to stem rust. This linkage appeared to be broken in the F₂ progeny from the cross with T. spelta but not in the progeny from the allohexaploid spelt.

Synthetic T. spelta and T. spelta were crossed with each other, with the Supremo variety and Strain 131 of T. aestivum, an allohexaploid of T. durum x Ae. squarrosa, another allohexaploid of T. timopheevi x Ae. squarrosa, a selection from (T. aestivum x Secales cereale) x Agropyron elongatum x T. aestivum (var. Cheyenne) and a selection from T. aestivum (var. Marquillo) x A. elongatum. All strains were morphologically stable. The F₁, F₂, and BC₁ plants were classified for fertility. All F₁ plants from the following crosses were essentially sterile: T. spelta x synthetic T. spelta, and the reciprocal T. spelta x the T. timopheevi allohexaploid, and the wheat-rye-Agropyron x synthetic T. spelta. Both spelt varieties produced highly fertile F₂ plants from the cross with Supremo and fairly fertile F₂ plants from the cross with Selection 131. Most of the F₂ plants from the cross of the wheat-rye-Agropyron x T. spelta were above 80 per cent in fertility. A majority of the F₂ plants from the cross of the

¹Doctoral thesis no. 1638, submitted March 8, 1955. Chairman of committee, I.J. Johnson, Department of Agronomy.

²B.S., Texas A. and M. College, College Station, Texas, 1940. M.S., *ibid.*, 1950.

T. durum allohexaploid x synthetic T. spelta were in the 41 to 60 per cent fertility class. The T. durum allohexaploid and T. spelta apparently had complementary dominant genes for lethality, as all F_1 plants from crosses between the two were lethal. A majority of the F_2 plants from the cross of synthetic T. spelta with the T. timopheevi allohexaploid were in the less than 20 per cent fertility class. Several selections resistant to all races of rust were made from the progeny of the (T. timopheevi allohexaploid x synthetic T. spelta) x Selection 131. No stem rust resistant F_2 segregates were obtained from crosses with the Agropyron selection, and most of these plants were in the less than 20 per cent fertility class. When an allohexaploid was one of the parents in a cross, the resulting F_2 population had a higher proportion of fertile plants than would be expected if the tetraploid species in the allohexaploid replaced the allohexaploid as one of the parents.

The number of plants with spelt and free-threshing spikes was determined for the F_2 and BC_1 generations from the crosses of T. spelta and synthetic T. spelta with the two T. aestivum varieties, the Agropyron selection and the wheat-rye-Agropyron. The F_2 plants in all crosses segregated into an approximate ratio of three spelt spikes to one free-threshing spike.

The F_1 plants from synthetic T. spelta x the Agropyron selection were perennials and approximately 23 per cent of the F_2 plants were perennials. No F_3 lines from these perennial F_2 plants produced more than 50 per cent perennial plants. Apparently this character was not simply inherited.

FEEDING HABITS OF EUROPEAN CORN BORER LARVAE ON SELECTED FIELD CORN INBREDS AND SINGLE CROSS HYBRIDS¹

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Department of Zoology and Entomology

A thorough knowledge of the feeding habits of Pyrausta nubilalis (Hbn.) is essential to the development of corn lines which are resistant to the establishment and survival of corn borer larvae. A review of the literature on the corn borer showed that, in spite of the extensive studies carried out with this pest, its feeding habits are incompletely known.

Plants artificially infested with corn borer eggs were used to study the stage of growth and location of larvae in relation to, (1) inbred line or single-cross hybrid, (2) date of infestation, and (3) length of time larvae had been feeding on the plants. Fifteen locations on each leaf were observed as primary feeding points. First-brood larvae were studied on the inbred lines WF9, M14, A295, Oh43, and W22, and on the single-cross hybrids WF9 x M14, Hy x W22, Hy x Oh43, and Oh43 x Oh51A. Second-brood larvae were studied on the single-cross hybrids only.

First Brood

Survival of first-brood borer larvae was much higher on the borer susceptible inbred lines WF9 and M14 than on the resistant lines A295, Oh43, and W22. The resistance of A295 and W22 apparently increased with plant growth or maturity, whereas the resistance of Oh43 remained static. WF9 and M14 were just as susceptible to borer establishment when infested on July 1 as when infested on June 24, 1953.

The greatest amount of first-brood borer mortality always occurred within 48 hours after egg hatch. There were significant decreases in borer survival on the inbreds when the plants were examined 2, 5, 15, and 30 days after infestation.

Essentially the same observations on borer survival were made on the single-cross hybrids as on the inbreds.

¹Doctoral thesis no. 1674, submitted June 3, 1955. Chairman of committee, Tom A. Brindley, Department of Zoology and Entomology.

²B.S., University of New Mexico, Albuquerque, N.M., 1950. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Agricultural Experiment Station.

Cornborer larvae followed the same general pattern of feeding on resistant and susceptible lines. However, localized areas of resistance and susceptibility were noted. Following establishment, the first-brood population shifted from feeding on the surface of the whorl leaves to boring into stalks, ear shoots and tassels. Larvae on single-cross hybrids followed the same feeding pattern as larvae on inbreds; however, larvae on the hybrids began shifting from surface feeding on whorl tissue to boring into plant tissue about ten days before larvae on inbreds.

M14 and WF9 were more susceptible to borer establishment on the whorl leaves than were A295, Oh43, and W22; furthermore, the susceptibility to whorl infestation was retained for a longer period. A295 appeared to be the most resistant to borer establishment among the whorl leaves. On the other hand, A295 was more susceptible to midrib invasion than any other inbred. Greater susceptibility to sheath feeding was found in W22. Both M14 and WF9 were quite susceptible to stalk invasion by borer larvae. WF9 x M14 was more susceptible to larval feeding on the whorl leaves, the collars and the tassels than were the other hybrids. Oh43 x Oh51A appeared to be especially resistant to midrib feeding by larvae.

Two days after artificial infestation of plants with borer eggs, only first-instar larvae were present. Both first- and second-instar larvae were found on plants examined five days after infestation. By 15 days after infestation the largest percentage of the larvae were in the third instar. Both fourth- and fifth-instar larvae were present in large numbers 30 days after infestation.

Changes in feeding sites on inbreds was associated with larval instars. First- and second-instar larvae were found primarily on the whorl leaves and secondarily on the sheath tissue. Third-instar larvae began tunneling into midribs, stalks, and ear shoots. Over 70 per cent of the full grown larvae and 61 per cent of the pupae were in the stalks.

Second Brood

In this study, hybrids resistant to first-brood corn borer larvae were not resistant to second-brood larvae. The leaf sheaths and collars were the primary points of establishment. This was associated with the accumulation of pollen and anthers in the leaf axils.

The rate of growth of second-brood larvae was similar to that of first-brood larvae. First- and second-instar larvae were found in largest numbers on collars and behind sheaths. Third-instar larvae, also found in the same areas, had tunneled into plant parts such as the midribs, stalks, and ears. Fourth instars were found on all parts of the plants. Full-grown larvae occurred in almost equal numbers in the stalks and behind and in the leaf sheaths. As the ears matured, larvae shifted from feeding primarily on the husks and ear tips and silks to feeding on the shanks and cobs, respectively.

Moist Area

Larvae were observed in relation to the band of moisture extending across the adaxial surfaces of the whorl leaf blades distal to the ligules. There was apparently no relation between height and width of moist areas and resistance or susceptibility of plants to borer establishment.

The greatest number of larvae fed on the first three leaves in the whorls of the inbreds and the first four or five leaves in the whorls of the single-cross hybrids. The largest percentages of larvae on any inbred or hybrid were usually within the first two inches above the moist area lower limit and within the first two or three inches below the upper limit. There was no relation between resistance and susceptibility to borer feeding and the location of larvae within the moist area of either inbreds or hybrids.

AN ANALOGUE COMPUTER FOR NETWORK ANALYZER STABILITY STUDIES¹CHARLES M. DAVIS²

Department of Electrical Engineering

Conventional a-c network analyzer generator units are imperfect analogues of the synchronous machines they represent. Having essentially zero-phase regulation, they are unable to simulate rotor oscillations or to adjust their phase angle in order to maintain constant output power. This means continual manual adjustment of the phase-angle control during load-flow and stability studies.

An electro-mechanical analogue has been developed and will be incorporated into the generator units of the 10-kc Network Analyzer at Iowa State College, which simulates in conjunction with the power amplifier the rotor inertia and the governor of the actual machine.

An accurate, stable, thermal-wattmeter provides a d-c signal for each amplifier and when compared with an input-power voltage results in an error voltage which corresponds to the accelerating torque on the rotor. After amplification by a magnetic amplifier, this voltage is integrated, once by a simple electronic integrator and then by a d-c velocity servo with rate feedback. The servo motor through a gear reducer drives a phase shifting transformer which provides the input signal to the power amplifier. Consequently, the phase of the output voltage varies according to the differential equation of motion of the rotor. For constant power performance in load-flow studies, the rotor is over-damped and the system becomes essentially a stable positioning scheme.

¹Doctoral thesis no. 1625, submitted December 13, 1954. Chairman of committee, W.B. Boast, Department of Electrical Engineering.

²B.S., California Institute of Technology, Pasadena, Calif., 1945. M.S., *ibid.*, 1946. Associate Professor.

ANALYTICAL APPLICATIONS OF THE REACTION OF THORIUM
WITH BENZENEPHOSPHONIC ACID AND ITS DERIVATIVES¹RODNEY JAMES DAVIS²

Department of Chemistry

For many years organic arsonic acids have been developed and used analytically. It was considered of interest and value to investigate analogous phosphonic acids.

Thermogravimetric curves of the thorium compound of benzenephosphonic acid showed four weight plateaus. The temperature ranges of stability of the corresponding compounds were roughly 100° to 210°C for compound (I), 250° to 450°C for compound (II), 500° to 800°C for compound (III) and 900° to 1200°C for compound (IV).

Thorium determinations based on the amount of thorium used and the precipitate weights dried at 150°C showed 38.76 per cent thorium for compound (I). Filtrates gave negative thorium tests with ammonia. Spectrophotometric determination gave 52.4 per cent benzenephosphonate and conductimetric, oscillometric and adsorption indicator titrations showed a 1:2 ratio of thorium to benzene phosphonic acid in compound (I). These data indicate that compound (I) is $\text{Th}(\text{C}_6\text{H}_5\text{PO}_3)_2 \cdot 3\text{H}_2\text{O}$.

The thorium determination in compound (II) gave 39.93 per cent thorium, indicating $\text{Th}(\text{C}_6\text{H}_5\text{PO}_3)_2 \cdot 2\text{H}_2\text{O}$. Similarly, 50.12 per cent thorium was found in compound (III) indicating $\text{Th}(\text{HPO}_4)_2 \cdot 2\text{H}_2\text{O}$.

Compound (IV) was analyzed for phosphorus by titration of phosphate with standard base after removal of thorium as the fluoride. The method was proved by analysis of primary standard disodium hydrogen phosphate. Compound (IV) was shown to contain 14.6 per cent phosphorus. Assuming no thorium to be lost on ignition to compound

¹Doctoral thesis no. 1598, submitted September 14, 1954. Chairman of Committee, Charles Banks, Department of Chemistry.

²B.S., University of New Hampshire, Durham, N.H., 1948. M.S., *ibid.*, 1950. Research Assistant, Chemistry and Institute for Atomic Research.

(IV), the calculated thorium to phosphorus ratio was 0.499. This assurance that the thorium to phosphorus ratio remains constant through the entire ignition substantiates the suggested formulae of compounds (II) and (III). The determination of thorium in compound (IV) showed 54.66 per cent thorium. The phosphorus and thorium determinations indicated that compound (IV) was $\text{Th}(\text{HPO}_4)_2$.

Pyrolysis data showed that phosphobenzene precipitated the same thorium compound as benzenephosphonic acid. The quality of the precipitate was not improved. Dimethylbenzenephosphonate precipitated a compound of much higher molecular weight. It is probable that the reaction involved the half hydrolyzed ester. Benzenephosphondiamide and benzenephosphondianilide were tested, in the form of glacial acetic acid solutions, as precipitating agents for thorium. It was found that both reagents precipitate on adding to the aqueous thorium solution.

The following gravimetric method for thorium, using benzenephosphonic acid, is recommended:

1. Take sample solutions containing from 0.04 to 0.3 g of thorium.
2. Add 150 ml of 1:3 concentrated hydrochloric acid and heat to boiling.
3. Add 50 ml of a 2.5 per cent solution of benzenephosphonic acid.
4. Boil for about 1 hour.
5. Cool and dilute with distilled water to 500 ml.
6. Adjust the pH with concentrated ammonia to 0.5-1.0.
7. Allow to settle overnight.
8. Collect precipitate on filter crucibles and wash six times with hydrochloric acid of pH 0.5-1.0.
9. Dry at 140° to 180°C to constant weight.
10. The gravimetric factor for thorium is 0.38793.

A series of 22 analyses showed a probable error of 3.2 parts per thousand. The average constant error was +0.6 parts per thousand and is not significant in view of the precision observed.

An interference study was made using molar quantities of interfering substances one-fourth to twice that of the thorium taken as chlorides, perchlorates, nitrates, or sulfates. None of these anions interfere. There appears to be a small positive interference from most cations, perhaps due to adsorption. The following interfered to an extent of zero to 1 per cent: Na(I), K(I), Be(II), Mg(II), Ca(II), Sr(II), Ba(II), Cu(II), Zn(II), Cd(II), Hg(II), Pb(II), Mn(II), Co(II), Al(III), La(III), As(III), Bi(III), Ni(II), Cr(III), Ce(III), and V(IV). Serious interference included Ag(I), Tl(I), Ti(IV), Sb(III), Fe(III), Zr(IV), Sn(IV), and U(VI).

Larger amounts of Ce(III) interfere seriously. A positive error of about 1 per cent was observed up to equimolar amounts of cerium in thorium. The error increases with the amount of cerium present to 14 per cent if the molar ratio of cerium to thorium is increased to 5.

Tests with 13 indicators, most of which had previously been used as adsorption indicators showed that bromphenol blue gave a reasonably sharp end point in 50 per cent alcohol at a pH from 3 to 4.5. A series of 15 titrations on samples of thorium nitrate containing 6 to 97 mg of thorium showed an error of about 1 per cent. The method cannot be highly recommended on the basis of the data available.

The solubility of thorium benzenephosphonate 3-hydrate was determined at pH values from 0.48 to 1.96. From eight solubility measurements, solubility product values from 0.68×10^{-31} to 5.41×10^{-31} were observed, the average being 3×10^{-31} .

The pK' values of benzenephosphonic acid were determined potentiometrically and spectrophotometrically. The values found were 0.91 and 6.41 from the former method and 0.96 and 6.51 from the latter.

Absorption spectra of $\text{C}_6\text{H}_5\text{PO}_3^-$, $\text{C}_6\text{H}_5\text{PO}_3\text{H}^-$, and $\text{C}_6\text{H}_5\text{PO}_3\text{H}_2$ in the range 250 to 290 μ were reported. Spectral data for a postulated $\text{C}_6\text{H}_5\text{PO}_3\text{H}_3^+$ in concentrated perchloric acid are reported. The molar absorptivities at wavelengths of maximum absorption for $\text{C}_6\text{H}_5\text{PO}_3^-$ were 174 at 252.4 μ , 242 at 258.4 μ , 197 at 262.5 μ , 202 at 264.6 μ , and 129 at 268.8 μ . Similar data for $\text{C}_6\text{H}_5\text{PO}_3\text{H}^-$ were 218 at 252.2 μ , 325 at 258.1 μ , 416 at 262.7 μ , and 325 at 269.6 μ . For $\text{C}_6\text{H}_5\text{PO}_3\text{H}_2$ the values were 505 at 257.3 μ , 690 at 263.6 μ , and 573 at 270.1 μ . The apparent maximum molar absorptivities of the postulated $\text{C}_6\text{H}_5\text{PO}_3\text{H}_3^+$ specie and their positions were 938 at 260.3 μ , 1288 at 265.5 μ , and 1059 at 272.4 μ .

KINETICS OF THE REACTION BETWEEN THORIUM AND WATER VAPOR¹BRUCE E. DEAL²

Department of Chemistry

Thorium metal quickly tarnishes in an atmosphere of water vapor above 150°C to form different-appearing coatings, depending on the temperature range. Because of the increasing importance of thorium and related metals in the field of atomic energy, a program was initiated to study the kinetics of the reaction between thorium and water vapor.

Three variables, time, temperature, and pressure, have been reported in the literature as having the greatest effect on oxidation reactions. The first variable, time, has been investigated most completely, with three rate laws being established. These are the linear law, the parabolic law, and the logarithmic law. Each is based on the fact that a straight line is obtained when a function of the amount of reacted species is plotted against time. It was shown that the logarithmic equation, $w = k \ln(1 + at)$, where "w" is the amount of reacted material per unit area, "t" is the time and "k" and "a" are constants, was obeyed by the data obtained in the thorium-water vapor studies. The exact mechanisms for each of the three rate laws is not known, but the most recent studies have indicated that both the parabolic and logarithmic laws are based on the fact that diffusion of some species through the growing product-coating is the rate-determining step. The logarithmic law is followed when there is migration of some species through flaw-paths or zones of loose structure in the reaction-coating, and these species are blocked in some statistical manner.

A form of the Arrhenius equation, $\ln k = -E/RT + \text{constant}$, has been applied to metal oxidation studies to illustrate temperature dependence, where "k" is the reaction rate constant, "E" the activation energy of the reaction, "R" the gas constant and "T" the absolute temperature. If $\ln k$ is plotted against $1/T$, and a straight line is obtained, the activation energy "E" may be obtained from the slope.

The most important relationship showing pressure dependence of metal oxidations is based on gas-solid diffusion phenomena. The general equation $k = -C_p^n e^{-b/T} + D$, where "k" is the rate constant; "p," the pressure; "T," the absolute temperature; and "C," "n," "b," and "D" are constants, has been proposed. The exact mechanism of the reaction determines the value of the constant "n."

The methods of following the thorium-water vapor reactions were used. The first was based on the fact that hydrogen is produced quantitatively in the reaction as is shown by the equation $\text{Th} + 2\text{H}_2\text{O} \longrightarrow \text{ThO}_2 + 2\text{H}_2$. A manometric apparatus was constructed which included a recording manometer, a reaction tube placed in a furnace and an inlet for introducing water into the system. As hydrogen was evolved by the reaction of water vapor with thorium, its increasing pressure was recorded and converted to oxide weight-gain. The second apparatus was based on a gravimetric method where direct weight-gain measurements were made. It consisted essentially of a quartz-fiber microbalance, so situated in an all-glass system that the thorium sample could be suspended inside a small furnace. Both the manometric and gravimetric systems were designed so that either thorium-temperature or water-vapor pressure could be varied while the other was held constant.

For either reaction, thorium metal was machined to cylinders of the proper dimensions and allowed to react with water vapor. Reaction temperatures ranged from 200° to 600°C and vapor pressures were varied from 25 to 100 mm of Hg.

Examination of the thorium-water vapor reaction products by X-ray diffraction and mass spectrometry techniques indicated only ThO_2 and H_2 were formed. Three different-appearing oxide coatings were observed, depending on the temperature range. Between 200° and 275° a black oxide coat was formed; from 300° to 425° a white or gray coat was observed, and from 450° to 550° the coating was metallic in appearance. X-ray diffraction data of the three different-appearing, reaction-product coatings indicated small, imperfect, glassy crystals at the lower temperature range, while at the higher temperature, definite and more perfect crystals were formed.

¹Doctoral thesis no. 1647, submitted April 1, 1955. Chairman of Committee, F.R. Duke, Department of Chemistry.

²A.B. Nebraska Wesleyan College, Lincoln, Nebr., 1950. M.S. Iowa State College, Ames, Iowa, 1953. Research Assistant, Chemistry and Institute for Atomic Research.

As mentioned above, the logarithmic rate law was found to best fit the reaction data. A value of the constant "a" was empirically determined to be 0.45. The reactions were found to be both temperature and pressure dependent. Plots of rate constant versus temperature indicated the three regions of different-appearing products. Rate constant values increased to a point at 275°, at which temperature a slight drop was observed. This drop was followed by increasing values again up to a maximum at 400°. The values rapidly decreased to a minimum at 500° followed by another increase through the highest temperature investigated, 600°. Similar plots were observed at three different pressures: 40, 70, and 100 mm of Hg. Plots of pressure versus rate constants indicated a first-order dependence of the reaction upon vapor pressure.

Plots were drawn of logarithm "k" versus 1/T for the three pressure ranges. Parallel straight lines were observed and an average value of 6.44 ± 0.75 kcal/mole was calculated for the activation energy of the thorium-water vapor reaction. The plots included both manometric and gravimetric data, and close agreement was observed in most regions. One exception was in the 350° to 400° temperature range and at a 40-mm vapor pressure. In this case the gravimetric rate constants had much larger values than those obtained by manometric methods.

Several experiments were carried out for the purpose of determining the mechanism of the reaction. A platinum marker experiment indicated that a diffusion inward of water molecules or a related species could be the rate-determining step. This followed from the fact that after a thorium-water vapor reaction, a platinum marker (which had previously been level with the thorium surface) was observed to be well above the metal-oxide interface. The first-order dependence of the reaction on water vapor pressure substantiates the possibility of water diffusion.

Vacuum fusion experiments indicated that hydrogen was adsorbed or diffused into the thorium during the reactions, especially at higher temperatures and low water vapor pressures. Small intergranular and intragranular particles observed in microphotographs of the reacted specimens are believed to be hydrides.

DORMANCY IN SEEDS OF *AGROPYRON SMITHII*,
DIGITARIA SANGUINALIS, AND *POA PRATENSIS*¹

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Seed dormancy presents specific problems to agriculturists and biologists. The seeds of the majority of wild plants are dormant, and specialists who desire to grow wild plants for experimental purposes are invariably confronted with dormancy. In many species of agricultural importance, seed dormancy has been greatly reduced through selection. In others, however, particularly the range grasses, flowers, herbs, and ornamental trees and shrubs, seed dormancy makes propagation by seeds difficult. Dormancy in grass seeds is of particular interest because of the agricultural importance of this plant group.

These studies were undertaken to determine the factors involved in dormancy in seeds of three grasses: western wheatgrass, *Agropyron smithii* Rydb., a range grass; crabgrass, *Digitaria sanguinalis* (L.) Scop., a weed; and Kentucky bluegrass, *Poa pratensis* L., an important pasture and lawn grass. The seed samples used in the studies were obtained from commercial sources (western wheatgrass) or by hand harvesting plants in the vicinity of Ames, Iowa (crabgrass, Kentucky bluegrass). The effect of various treatments on dormancy was evaluated in terms of germinative responses. Germination tests were carried out in petri dishes in quartz sand (western wheatgrass, Kentucky bluegrass) or on filter paper (crabgrass) at an alternating temperature of 15-30°C.

Studies on the relation of the seed coat to dormancy showed that rupturing this structure allowed complete germination of each kind of seed. Further tests demonstrated

¹Doctoral thesis no. 1648, submitted April 11, 1955. Chairman of Committee, Duane Isely, Department of Botany and Plant Pathology.

²B.S., Southwestern Louisiana Institute, Lafayette, La., 1951. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Agricultural Experiment Station.

that the seed coats of these grass seeds were not impermeable to water as the quantity of water absorbed by dormant and nondormant seeds was essentially equivalent. Therefore, a restriction imposed by the seed coat on gaseous exchange appeared to be involved.

The effect of light on dormancy was studied by supplying light for nine hours per day for periods up to 32 days. The germination of crabgrass and Kentucky bluegrass was stimulated by light. The degree of stimulation was dependent upon the number of days light was supplied during the germination period. The need of light for germination, however, was obviated by breaking the seed coats. On the other hand, light inhibited the germination of seeds of western wheatgrass. This effect was to some extent residual, i.e., subsequent exposure of the seeds to darkness did not completely offset the effect of light. Breaking the seed coat of western wheatgrass did not overcome the inhibiting effect of light. Many investigators have reported that germination of dormant grass seeds was favored by light; however, only a few instances of inhibition of grass seed germination by light have been reported.

Low concentration (0.25 per cent) solutions of various nitrate compounds employed for moistening the substrata stimulated germination of each species. As in the case of light, the need for this treatment was eliminated by breaking the seed coats. Soaking the seeds of crabgrass and western wheatgrass in ethylene chlorohydrin solutions (0.5 - 0.125 per cent) for 24 or 48 hours also promoted germination. This treatment was ineffective in promoting germination of Kentucky bluegrass. Ethylene chlorohydrin treatment also counteracted the inhibiting effects of light on germination of western wheatgrass.

Subjecting the seeds to 10°C for five days (prechilling) before placing them at 15 - 30°C for germination promoted germination of Kentucky bluegrass, had little effect on crabgrass germination, and induced dormancy in seeds of western wheatgrass. This induced dormancy was overcome by breaking the seed coat. Seed dormancy in crabgrass was completely overcome by stratification in moist sand at 2° - 4°C for two months. Shorter periods of stratification were also effective in forcing complete germination when light was supplied; increased but incomplete germination was obtained in darkness.

Soaking the seeds of crabgrass in running water, and to a lesser extent in standing water, promoted germination. This treatment was ineffective in stimulating germination of western wheatgrass and Kentucky bluegrass. The response obtained by soaking crabgrass seeds in water suggested that possibly some substance (or substances) inhibiting germination was removed. Further experiments indicated that aqueous extracts prepared from dormant crabgrass seeds and from hulls (undeveloped spikelets) removed from dormant seed samples inhibited germination of nondormant crabgrass. The inhibitive property of the extract was not diminished by boiling for periods up to 30 minutes. Similar extracts prepared from nondormant seeds were not inhibitive.

The influence of variation in the partial pressure of oxygen on germination of dormant seeds was studied by employing pint or quart jars as chambers. The atmospheric composition of the chambers was adjusted by displacement of water by oxygen and nitrogen. Increasing the partial pressure of oxygen promoted germination of western wheatgrass, but had no effect on germination of crabgrass. Decreasing the partial pressure of oxygen retarded germination of both species; however, germination of intact seeds was retarded much more than germination of seeds whose coats were ruptured. Solutions of nitrate compounds and ethylene chlorohydrin treatment were ineffective in promoting germination under reduced levels of oxygen.

Germination of western wheatgrass and crabgrass seeds was higher in soil than in sand. In the case of western wheatgrass, the data indicated that the germination-promoting effect of soil could be attributed to the presence of soluble nitrate compounds in the soil. However, other factors seemed to be involved in the germination-promoting effect of soil on seeds of crabgrass, possibly the adsorption of inhibiting substances leached from the seeds by soil moisture.

It is suggested that dormancy in each of the three kinds of seeds investigated is largely conditioned by a restriction imposed on gaseous exchange by the seed coat. Supplementary factors, however, are also involved in seed dormancy in western wheatgrass and crabgrass, i.e., direct inhibition of germination by light and a germination inhibitor, respectively.

DIFFUSION AND ADOPTION OF APPROVED FARM PRACTICES IN ELEVEN COUNTIES IN SOUTHWEST VIRGINIA¹

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The purpose of this research was to investigate the diffusion of improved farming practices. The data were gathered in 1951 through the use of schedule interviews with farm operators in the following 11 southwestern Virginia counties: Bland, Dickenson, Grayson, Lee, Russell, Scott, Smythe, Tazewell, Washington, Wise, and Wythe. The Tennessee Valley Authority (TVA) test demonstration farm units furnished the basis for the investigation. A stratified random sample of 150 demonstration farms was drawn from the list of demonstration farms active as of January 1, 1951. Limitations of time and funds required a subsampling of the original sample and twenty-five demonstrators were drawn, around each of which twenty farmers were selected for interview relative to the adoption of ten farming practices approved by TVA. The total number of schedules completed and usable was 149 for the demonstrators and 493 for the nondemonstrators.

Four general objectives formed the basis for the analysis procedure. The first three objectives were examined, using data obtained from both the demonstrators and nondemonstrators. The fourth objective was analyzed for data obtained from the nondemonstrators only. Hypotheses were formulated with respect to each of these objectives and subjected to test during the analysis. The results of the testing of these hypotheses are indicated for three levels of support. The phrase "conclusively supported" is used to indicate relationships statistically significant at the .01 and .02 levels of probability. The term "supported" is used to indicate relationships statistically significant at the .05 level of probability. The term "indicated" is used for cases where the hypotheses were not subjected to test by statistical measures of significance, but where the evidence was favorable to the hypotheses.

The first objective was to compare the operators of the TVA test demonstration farms with operators not in the demonstration program on the basis of selected socio-economic characteristics. Support for the following hypotheses was indicated by means of graphical analysis. 1) The farms operated by the demonstration farmers are larger than those operated by the nondemonstration farmers. 2) The demonstrators are predominantly owner operators while the nondemonstrators are predominantly tenant operators. 3) The demonstrators have a higher proportion of their number in the younger ages than have the nondemonstrators. 4) The educational level of the demonstrators is higher than that of the nondemonstrators. The other hypothesis examined under this objective had no indicated support. This hypothesis was that the demonstrators have lived on the same farm a greater average number of years than the nondemonstrators.

The second objective was to study the process by which the spread and acceptance of selected farm practices occurs. Support for the following hypotheses was indicated by means of graphical and tabular analysis. 1) There is a definite pattern of adoption over time which tends to approach Chapin's "S" curve of cultural change. Support was indicated for this hypothesis in the case of the use of hybrid seed corn, but was not so clearly indicated for the other practices. 2) The lag in years between initial contact with the practices and the first trial of the practices is longer than the time lag between the initial trial of the practices and the adoption of the practices.

The third objective was to analyze the role played by various diffusion media in the process of the spread and acceptance of these approved practices. Support was indicated for the following hypotheses by means of tabular analysis. 1) Following initial contact with the practices, agencies such as the Extension Service become numerically more important as sources of additional information. 2) Demonstrators use the Extension Service, college bulletins, and other less personal sources to a greater extent than do nondemonstrators.

The other two hypotheses examined were not supported. 1) Newspapers, magazines, and other mass media are numerically most important as initial contacts with approved

¹ Doctoral thesis no. 1590, submitted August 12, 1954. Chairman of Committee, Ray E. Wakeley, Department of Economics and Sociology.

² B.A., Pennsylvania State College, State College, Penna., 1948. M.S., *ibid.*, 1949. Instructor.

farm practices. Neighbors and relatives were numerically most important as original sources of information for the nondemonstrators while the Extension Service was numerically most important for the demonstrators. The ranking of radio with reference to its importance as a source of information concerning farming practices was in direct conflict with the findings of other studies. Radio was ranked very low in importance by both demonstrators and nondemonstrators in this area of Virginia. In most of the previous studies, radio was ranked very high as a source of information concerning farming practices. 2) Neighbors and friends are the most important contacts numerically in securing the individual's trial of the practices. Neighbors were ranked in a relatively low position as influences leading to trial of the approved practices. Result demonstrations were numerically the most important influences. These were not result demonstrations in the sense of experiments, but rather in terms of observing good results either on the individual's own farm or on that of some other practical farmer in the area.

A very important finding with regard to sources of information was that the sources for original contacts with the practices differed from those influencing trial and adoption of the practices. This suggests that those associated with action programs should select certain media for the dissemination of information concerning new or improved practices and select other media for use in securing adoptions of these practices by farm operators.

The fourth objective was to analyze the relationship of selected socio-economic factors to the adoption or nonadoption of these farm practices. The following hypotheses were conclusively supported by the analysis of the data from this research. 1) The number of years of schooling completed is positively associated with the adoption of the approved practices. 2) Farm size in acres operated is positively associated with the adoption of the approved practices. 3) Socio-economic status of the farm operator is positively associated with the adoption of approved practices. 4) The age of the farm operator is negatively associated with the adoption of approved practices. The remaining hypothesis that the distance from the demonstration farm is negatively associated with the adoption of approved practices was not supported.

FLOODING CHARACTERISTICS OF A PULSE COLUMN¹

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An investigation was made of flooding in a 1-inch diameter pulse column, using the hexone-water system. A 10-plate column was constructed of stacked glass sections held in compression by four tie rods. The plates, spaced 2 inches apart, were perforated with 1/32-inch diameter holes to give a plate free area of 25 per cent.

Flooding was demonstrated to be caused either by inadequate pulsation or by excessive pulsation. Earlier investigators concluded that the pulsed volume velocity equals the total throughput at incipient flooding due to inadequate pulsation, but such a conclusion was shown to be an oversimplification. A theoretical flooding equation,

$$V_r = V_p \cosh(G/\pi V_p) - G/2 - L,$$

was derived, where V_r is the rate of recycle (or vertical back mixing), V_p is the pulsed volume velocity (the product of pulse volume and frequency), G is the organic flow rate, and L is the aqueous flow rate. When $V_r > 0$, recycle was present; when $V_r = 0$, incipient flooding existed; and when $V_r < 0$, flooding due to inadequate pulsation occurred. Flooding data for conditions of inadequate pulsation were well correlated by use of this equation.

Incipient flooding predicted by the flooding equation was a function only of the primary operating variables, but the range of applicability of the equation was limited by

¹Doctoral thesis no. 1611, submitted December 2, 1954. Chairman of Committee, G. H. Beyer, Department of Chemical Engineering.

²B.S., University of Arkansas, Fayetteville, Ark., 1950. M.S., Iowa State College, Ames, Iowa, 1953. Research Assistant, Institute for Atomic Research.

the alternate type of flooding caused by excessive pulsation. The equation permitted the calculation of the amount of recycle existing in a pulse column at various conditions of operation. Since recycle represents a deterioration of true countercurrent operation, recycle rate possibly may prove useful as a correlating device in pulse column extraction studies.

Pulse column performance was observed to be extremely sensitive to plate wetting. Variation in the plate wetting characteristics as produced by a nitric acid wash was shown to result in more than a twofold increase in the capacity of a pulse column. Hold-up was apparently less sensitive than flooding to changes in plate wetting. Variation in the plate wetting characteristics during the course of this investigation restricted the development of any correlation of flooding caused by excessive pulsation or of pulse column hold-up.

A simple procedure was demonstrated for measuring the hold-up of a pulse column. Success of the method required that flow of both phases to the column and the pulsation be stopped instantly and simultaneously and that no counterflow occur in the column when not pulsed. When such requirements were met, it was possible to effectively "freeze" the contents of the column while at steady state operation and make hold-up measurements with a ruler.

A satisfactory method was developed for the determination of flooding caused by excessive pulsation. The flooding capacity was obtained when the column was operated with an interface at both the top and the bottom of the column. By keeping the position of these interfaces constant, the flow rates to the end sections of the column could be balanced against the flow through the contacting section. Under these conditions the maximum flow through the column without flooding was established. This method was rapid, simple, and inhibited emulsification in the bottom end section of the column.

The transition from flooding caused by inadequate pulsation to flooding caused by excessive pulsation must be investigated further before the limitations of the theoretical flooding equation can be defined. Studies which will provide a correlation of flooding conditions due to excessive pulsation are recommended. However, until a basis for establishing the effect, as well as a characteristic measurement, of plate wetting is developed, accurate prediction of pulse column performance will not be possible.

COAL SPOIL-BANK MATERIALS AS A MEDIUM FOR PLANT GROWTH¹

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Strip mining has become increasingly important as a method of removing coal from Iowa coal fields. This method of mining produces areas of newly exposed geologic material known as spoil banks. Little was known about the physical and chemical properties of this material. The purpose of this investigation was to characterize coal spoil-bank materials as a medium for plant growth.

Preliminary investigations into the extent, location, and nature of the problem indicated that in 1952 approximately 93 per cent of the Iowa coal strip-mine lands were located within 10 miles of the Des Moines River. The northernmost area was located near Runnells and the strip-mining region extended southeast along the Des Moines River to Farmington.

Spoil-bank acidity was found to be a serious problem in Iowa. Toxic spoil materials (pH less than 4.0) which were unsuitable for plant growth, were found on the surface of approximately 38 per cent of Iowa strip-mine areas. Textures of the surveyed spoil materials were found to be favorable for plant growth. Most materials were silty clay loam to loam in texture.

Studies of the development of acidity in Pennsylvanian shales indicated that low pH values were related to large amounts of oxidizable sulfur. The rate of development and the level of spoil-bank acidity appeared to be influenced by the type, amount, and fineness of the sulfur compounds and the presence of other modifying chemical compounds.

¹Doctoral thesis no. 1635, submitted March 1, 1955. Chairmen of Committee, A.L. McComb, Department of Forestry, and F.F. Riecken, Department of Agronomy.

²B.S., Iowa State College, Ames, Iowa, 1949. M.S., *ibid.*, 1950. Research Associate.

Toxic materials usually have a total sulfur content of from 2 to 3 per cent. Most materials develop maximum acidity within 6 months and studies made on shale-derived soils indicated that improvement of toxic and very acid shales by weathering and leaching would be an extremely slow process.

Liming and fertilizer experiments on several of the major types of spoil materials, using tomato as an indicator plant, demonstrated that phosphorus was the plant nutrient first limiting growth on toxic (limed), very acid, and acid Pennsylvanian shales. Levels of lime required for toxic materials were extremely high (15 to 20 tons per acre) and greenhouse work indicated liming effects were temporary in nature and total applications of as much as 60 tons per acre might be needed to maintain desired pH levels. The NPK treatments gave the highest yields on the shale materials which were investigated. In studies on Wisconsin loess and Kansan glacial till, the NP treatment produced the highest yields.

Investigations of the characteristics of Iowa coal spoil-bank areas resulted in dividing spoil-bank materials into seven principal types. Texture, pH, soluble salts, cation exchange capacity, total exchangeable bases, exchangeable calcium, available phosphorus, and available potassium were determined for each material. Sulfates and total nitrogen were determined for some of the materials. Wisconsin loess, Kansan glacial till, acid buff shales, Pleistocene and Pennsylvanian sands, and Black calcareous shales were found to be best suited for plant growth. Toxic gray shales and brownstone shales were found to be poorly suited for plant growth. Poor growth appeared to be associated with low pH (less than 4.0), high soluble salts, and high levels of iron and aluminum.

Normally developed shale-derived soils found in the Des Moines River coal district were investigated as a means of predicting the potentialities of shale spoil-bank materials. Results of investigations on four soils indicated soils derived from Pennsylvanian shale inherently will be of low fertility. The occurrence of toxic and very acid horizons in the studied profiles suggested that the improvement of acidity by weathering and leaching was not a rapid process.

Replicated tree studies were established on nine spoil-bank areas in 1952 and 1953. Based on these nine studies and results of studies in adjacent states, tree species were suggested for use on six of the seven types of spoil materials. Pinus banksiana, P. resinosa, P. virginiana, P. strobus, P. nigra, P. sylvestris, Juniperus virginiana, Fraxinus pennsylvanica, Platanus occidentalis, Populus deltoides, Ulmus americana, and Robinia pseudoacacia had the best survival and early growth and were suggested for use in revegetation on properly selected sites. Spoil materials of pH 5 to 7 appeared to be best suited for tree growth. Survival of tree species was not satisfactory at pH levels below 4.0. Juniperus virginiana was the only conifer with satisfactory survival on alkaline spoil materials. However, Populus deltoides, Ulmus americana, Fraxinus pennsylvanica, and Robinia pseudoacacia showed promise on these areas.

Grasses, legumes, and grass-legume mixtures were seeded on 16 areas over a 3-year period. Based upon these investigations and investigations in neighboring states, forage species were considered as suitable for cover crops or forage production on five types of spoil-bank materials. Melilotus officinalis, M. alba, Lespedeza stipulacea, Medicago sativa, Lotus corniculatus, Agropyron intermedium, Elymus canadensis, Bromus inermis, Dactylis glomerata, Phleum pratense, and Festuca arundinacea produced the most promising stands of the species investigated.

Early spring seeding of legumes on newly stripped spoil areas has been the most successful method of establishing good stands of legumes. Light raking of the planting site after the seed was sown more than doubled the stand densities. Grasses, because of their nitrogen requirements, were best established either by seeding the grasses as grass-legume mixtures or seeding grasses into established legume stands. Raking also improved the density of grass stands.

Spoil-bank acidity was found to be the major problem related to revegetation of these areas. An investigation into methods of improving the physical and chemical properties of spoil-bank materials indicated modification of strip-mining methods was the most feasible way of spoil-bank improvement. The modifications would involve identification of potentially troublesome overburden and taking special precautions to see that this material was covered by one of the better types of spoil materials. Wider use of strip-mining techniques similar to the presently used "bench method" would greatly improve the chemical and physical properties of the surface materials.

STRUCTURAL STUDIES ON INSULIN¹RUDOLPH HENRY ELLINGER²

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Sanger and his co-workers (1,2) have reported an amino acid residue sequence for insulin. The reported sequences of the N-terminal pentapeptides of the two peptide chains of insulin were, for Fraction A, glycyl-isoleucyl-valyl-glutamyl-glutamic acid, and for Fraction B, phenylalanyl-valyl-aspartyl-glutamyl-histidine.

Blaney (3) found phenylalanine, glycine, and valine in N-terminal residues of insulin by the subtractive microbiological assay method of Fox, Hurst, and Itschner (4) and confirmed his results by a modification of the Edman (5) method of amino acid sequence determination. Since Blaney's results (3) indicated the presence of an additional N-terminal residue to those found by Sanger and his co-workers (1,2), the N-terminal amino acid residue sequences of the insulin peptide chains were reinvestigated.

Blaney's modification (3) of the Edman phenylisothiocyanate (PTC) method (5) was used. PTC treatment of insulin with subsequent hydrolysis of the derivatized protein by vigorous aqueous acid hydrolysis produced the phenylthiohydantoin (PTH's) of the N-terminal amino acid residues. Ether extraction of the PTH's and their subsequent hydrolysis with barium hydroxide regenerated the parent amino acids which were identified by paper chromatography. Intense spots for phenylalanine, valine, and glycine and a weak spot for alanine occurred on the chromatograms of seven N-terminal residue determinations. A weak spot of an unidentified substance occurred on some of the chromatograms.

An investigation of the barium hydroxide hydrolysis of the synthetic PTH's of phenylalanine and glycine showed that the weak spots for alanine and the unidentified substance arose as the result of degradation during hydrolysis.

When the N-terminal bond of PTC-treated insulin was selectively split with anhydrous dioxane saturated with hydrogen chloride (dioxane-HCl) and the PTH's of the N-terminal amino acid residues were extracted and hydrolyzed, intense spots for only phenylalanine and glycine and weak spots for alanine appeared on paper chromatograms. When Sanger's 2,4-dinitrofluorobenzene (DNFB) method (6) was used to investigate the N-terminal residues of insulin, again only phenylalanine and glycine were indicated.

Insulin samples were given one, two, three, and four PTC treatments, respectively, with dioxane-HCl cleavage after each PTC treatment to provide four insulin samples, each successive sample with one less residue at the N-terminal ends of the remaining peptides. The PTH's were extracted, hydrolyzed, and chromatographed but so many spots were produced on the paper chromatograms that it was impossible to determine the positions of the amino acids in the insulin peptide chains. The intact residues of each successive sample were treated with DNFB to determine their N-terminal residues and thus to determine the sequence of the residues in the second, third, and fourth positions of the insulin peptide chains. The results agreed completely with the amino acid residue sequence proposed by Sanger and his co-workers (1,2).

The combination of the PTC method (using dioxane-HCl to selectively cleave the peptide bonds of the derivatized terminal amino acid residues) and DNFB method confirmed the N-terminal sequences of the amino acid residues in the first five positions of the peptide chains of insulin as proposed by Sanger and his co-workers (1,2). No evidence of valine was found when the N-terminal peptide bonds of PTC insulin were split with dioxane-HCl. When, however, the PTC treated insulin was vigorously hydrolyzed with 5.7 N hydrochloric acid, prominent spots for valine, phenylalanine, and glycine appeared on paper chromatograms of hydrolysates of the PTH's thus formed. The reason for the appearance of valine only as the result of vigorous acid hydrolysis of the peptide bonds and not during selective fission of the N-terminal bonds of PTC treated insulin, and not at all by the DNFB method of N-terminal amino acid residue determination cannot be determined from the data accumulated during the present investigation. An analysis of the results obtained does, however, provide some conclusions. Explanations for the appearance of valine could be, 1) that there is a third peptide chain with an N-terminal valine residue, 2) that the N-terminal and the adjacent

¹Doctoral thesis no. 1626, submitted December 13, 1954. Chairman of Committee, S.W. Fox, Department of Chemistry.

²B.S., Michigan State College, East Lansing, Mich., 1950. M.S., Iowa State College, Ames, Iowa, 1953. Graduate Assistant, Chemistry and Industrial Science Research Inst.

peptide bonds were cleaved to provide a valine residue from the second position of Fraction B, 3) that a proteolytic enzyme provided by a contaminating microorganism hydrolyzed a portion of the N-terminal peptide bonds of the Fraction B peptide chain and/or the penultimate peptide bond of the Fraction A peptide chain thus providing some N-terminal valine residues, 4) that there was incomplete hydrolysis of the N-terminal peptide bond of the Fraction B peptide chain so that phenylthioureido-phenylalanyl-valine was extracted and hydrolyzed with the PTH's, 5) that valine was extracted or carried over with the PTH's during their extraction from the PTC treated insulin hydrolysate, 6) that insulin contains an atypical derivative of valine, or 7) that insulin contains an atypical ring which is degraded to valine on alkaline hydrolysis.

The first four explanations are excluded on the basis of the results obtained from the combined PTC and DNFB methods. In each case DNP-derivatives of amino acid residues other than those expected from Sanger's structure should have appeared. Since none but the expected derivatives were isolated, and identified, the explanations are not valid. An investigation of the ability to extract valine showed that it is not extracted with ether. Another experiment showed that had valine been carried over during extraction of the PTH's, other amino acids would also have been carried over.

The presence of an atypical derivative of valine which has a free amino group and is attached to the insulin chains through bonds with its carboxyl group and its side chain is plausible. Penicillamine, a derivative of valine found in penicillin, could fit the requirements of such a residue if it were attached to the insulin molecule through a disulfide linkage.

An atypical ether-extractable ring which is resistant to acid hydrolysis but is split during alkaline hydrolysis is also possible. Rings such as the thiazole nucleus of thiamine and the thiazolidine ring of penicillin and perhaps of bacitracin are known. Other atypical linkages could be proposed on the basis of existing evidence resulting from the investigations of natural proteins and peptides.

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SOIL PROFILE DEVELOPMENT IN SANDY PARENT MATERIALS OF IOWA¹

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In Iowa there are some 135,000 acres of soil which have developed from sandy parent material. Information concerning the fertility status and the genetics of profile development of these sandy soils is quite incomplete. Therefore, both field and laboratory studies were employed in an attempt to accumulate information relevant to the factors of soil-plant relations and soil profile genesis. Detailed laboratory analyses were made on profiles which were typical of the Thurman, Chelsea, and Dickinson series.

Field studies were made to determine the extent, depth in the profile, and relative abundance of the iron and clay bands which were found in some of the sandy soils. Observations made in the field studies indicate that the iron and silicate clay enriched bands have a depth relation to the soil surface under virgin conditions. Also the bands occur often enough to indicate that the banding phenomenon is the usual rather than the

¹Doctoral thesis no. 1591, submitted August 13, 1954. Chairman of Committee, F. F. Riecken, Department of Agronomy

²B.S., Oklahoma A. and M. College, Stillwater, Okla. 1950. Instructor.

exception in profile genesis of sandy soils. The majority of the sandy areas were east and south of the major streams, suggesting that many of the sandy deposits have resulted from winds moving the material from the stream flood plains. Field observations in conjunction with the mechanical analyses seem to indicate that some of the sand deposits in the upland have resulted from a paha type of deposition. Other upland sands have evidently been deposited by water with only very local wind sorting. Data obtained by fractionation of the less than 2-micron clay indicate differential movement of the clay fractions in the profiles studied which have iron and silicate clay enriched bands present. In the profile studied in which no banding of iron and clay was evident, there was no apparent movement of clay size particles in the profile.

Data from the chemical analyses indicate a very small quantity of bases held in the exchangeable form. Exchangeable base content of the iron band layers was of the order of twice as high as in the interband layers. Exchangeable Ca to Mg ratios were lower in the bands than in the interband layers. The lower Ca to Mg ratio was taken to indicate that the bands were a B horizon. Exchangeable Ca to Mg ratios were higher in the profiles studied than those reported for other Gray-Brown Podzolic and Brunizem soils which have developed from finer textured material. However, the ratios were quite similar to those reported for the O'Neill series, a Brunizem soil developed from sandy parent material. Total nitrogen had somewhat the same distribution as did the exchangeable bases. The Thurman profile studied, which is classed as a Brunizem, had a nitrogen distribution more nearly like the Gray-Brown Podzolic soils or like the Chelsea profile studied. Therefore, polygenetics may possibly be used as an explanation for the profile characteristics which are probably relict to the present profile development.

Various experiments were executed in the laboratory in an attempt to produce iron bands in sand. Iron bands were produced in a four foot tube which was one inch in diameter, by filling the tube with iron containing sand and leaching the sand-filled tube with 0.01 normal oxalic acid solution. The bands were visually quite evident but were not sufficiently thick to sample for laboratory analysis. The development of bands in the laboratory is considered as additional proof that the bands of iron and clay enrichment observed in the field are the product of profile genesis. Upon drying, the sandy material in the upper part of the leaching tubes was quite strongly cemented. This cemented layer has many of the properties of the fragipans which have been described in loamy and silty soils.

A new grouping of soil profile symbols is suggested to designate multiple banding of iron and clay in a soil profile. It is suggested that A_2 be used for the interband layers and B_{1r} be used for the obvious bands of iron and clay. A grouping of these two symbols as $A_2B_{1r}^c$ with the superscript "c" to denote a complex, could be used to indicate the complete zone of banding.

It seemed logical from the investigation that the profiles studied which have iron and clay bands, should be included in the Gray-Brown Podzolic and Brunizem great soil groups to be separated from the modal soils at the high family level. Sandy profiles without iron and clay bands present could be separated at the low family level.

INFLUENCE OF NONPROTEIN CALORIES ON THE NITROGEN ECONOMY OF PROTEIN-DEPLETED RATS¹

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Four questions have been raised in the present investigation regarding the influence of nonprotein calories on the rate of catabolism characteristic of rats depleted of bodily reserves of protein and maintained on nitrogen-low rations of varying caloric value. Answers to these questions were sought within a specific experimental framework.

A protein-free ration providing energy from either carbohydrate alone or from a

¹Doctoral thesis no. 1584, submitted July 16, 1954. Chairman of Committee, Pearl Swanson, Department of Food and Nutrition.

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mixture of carbohydrate and fat was fed to adult male rats. The quantity of nitrogen excreted in the urine under the various experimental regimes imposed was used to measure rate of body catabolism. The respective rations were fed *ad libitum* for 18 days after which the nitrogen metabolism of the animals was measured for a five-day interval. The energy content of the diet then was reduced to approximately one-fourth of its original value, and after a four-day adjustment period another five-day metabolism test was conducted. Animals in a control group received the same rations in amounts that met their energy needs in the second metabolic interval. In one experiment, the rations administered in the metabolism test were fed until death intervened and urinary nitrogen was determined daily.

The four questions raised and the experimental work designed to answer the questions are presented below.

Are all fats equally effective in preventing excess catabolism of body protein induced by caloric restriction of protein-free diets? The effect of butterfat, lard, margarine fat, hydrogenated vegetable fat, and cottonseed oil, as well as of certain fat mixtures, was determined. Reactions of animals to the feeding of diets containing the different sources of fat at two caloric levels were compared to those of animals ingesting a low-fat diet. Fats apparently vary appreciably in their ability to spare body protein under the stress of caloric restriction. Of the single fats tested, cottonseed oil was the most effective; butterfat, the least effective. Margarine fat ranked second, while hydrogenated vegetable fat and lard were intermediate in effect. The lard-butterfat and lard-margarine fat combinations were the most effective fat mixtures, while the mixtures containing cottonseed oil were the least effective. Other mixtures were of intermediate value.

What properties of cottonseed oil are responsible for its protein-sparing effect? It was thought that the superiority of diets containing cottonseed oil in reducing catabolism caused by caloric restriction might reflect the high degree of unsaturation of the oil or its content of essential fatty acids. If the unsaturated fatty acids exert a protective influence, the feeding of a completely saturated fat should induce a negative response. A saturated preparation of coconut oil did prove ineffective when fed as the source of dietary fat, and in the next test, therefore, the low-fat ration was supplemented with a pure preparation of methyl linoleate. No decrease in the excretion of urinary nitrogen occurred. Thus, the favorable influence of cottonseed oil cannot be attributed to linoleic acid. Other unsaturated fatty acids present in cottonseed oil may be active, however. Or, its potency may be associated with the nonsaponifiable fraction of the fat molecule.

Does body fat act in the same manner as dietary fat in preventing excess catabolism of tissue protein in response to caloric restriction? Animals were starved until they reached a weight of 325 gm, after which they were subjected to the regular experimental metabolic regime. Individual rats in this test exhibited very uniform performance, especially in response to caloric restriction, suggesting that body reserves of fat may play a part in the body-sparing phenomenon.

What is the long-time effect upon the nitrogen metabolism of protein-depleted rats of feeding nitrogen-low rations of adequate and inadequate caloric value? Whether or not the apparent protein-sparing effect of cottonseed oil in diets of low energy value was a permanent or a transient phenomenon was studied as well as the extent to which the rate of nitrogen catabolism affected the time of survival of animals receiving the various test rations. Animals were fed in full and restricted quantities either the basal low-fat ration or the ration containing 20 per cent of cottonseed oil until death occurred. Nitrogen excreted in the urine by the rats was determined daily. As the period of caloric restriction lengthened, animals receiving low-fat, low-calorie diets excreted increasingly large quantities of urinary nitrogen daily over an interval of about 20 days. Then excretion of the constituent dropped from 240 to 180 mg per day. The animals survived caloric restriction for an average of 27 days. Animals receiving fat, in comparison, metabolized protein at a slower rate and life was prolonged considerably, i.e., 39 days after the initiation of caloric restriction. At no time did these rats excrete more than 150 mg of nitrogen per day. They exhibited a markedly low catabolism in the latter days of life (70 mg of urinary nitrogen per day).

Dietary fat behaved in a different manner when the same diets were fed in amounts that met the energy requirement of the rats. Rats receiving the fat diet in unrestricted amounts maintained the high excretion of nitrogen observed in the first period of the regular metabolism test for an average of 50 days when feeding the diet was continued. Then, in the remaining days of life, they decreased their excretion of nitrogen by

approximately one-half. On the other hand, the rats receiving the carbohydrate ration of full caloric value excreted considerably less nitrogen in the urine than did the fat-fed group in the first intervals of the experiment. As a result they survived on the average of 174 days instead of 121 days.

Thus, it has been shown that under specific experimental conditions, dietary fat may or may not play a role in the maintenance of nutrition over and beyond the provision of energy and essential fatty acids. It so acts only when a ration low in nitrogen is fed to male rats, depleted of body reserves of protein, in quantities inadequate to meet energy needs. Under these circumstances, certain specific dietary fats reduce the rate at which body tissue is catabolized with a resulting prolongation of life. On the other hand, fat in a protein-free diet of adequate energy value is associated with a shortened life span and an increased rate of catabolism.

Dietary fats vary in efficacy in decreasing the rate of nitrogen catabolism in protein-depleted male rats in response to caloric restriction of diets low in nitrogen. Of the various fats tested, cottonseed oil is the most efficient single fat in preventing the breakdown of body tissue that is associated with a reduction in the energy value of a protein-free diet.

COMPARISON OF LEGUMINOUS GREEN MANURES WITH INORGANIC NITROGEN IN ROTATIONS WITH CORN¹

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Department of Agronomy

An investigation was carried out at four locations in Iowa during the period 1951-1953, the major objective of which was to evaluate different legumes when used for green manure in the fall of the seeding year. Exploratory experiments with a large number of legumes with varying degrees of adaptation to Iowa were conducted for the purpose of estimating their potential value as green manures in Iowa. Major emphasis was placed upon the comparison of six legumes: Madrid biennial yellow sweetclover, Hubam annual sweetclover, Grimm alfalfa, southern-grown common alfalfa, medium red clover, and Ladino clover. The dry matter and nitrogen yields of both roots and tops of these six legumes were measured. Effects of the six legumes on a succeeding corn crop were evaluated in comparison with inorganic nitrogen fertilizer. Additional studies were carried out to compare availability to corn of nitrogen from freshly-cut and other organic materials.

Stands, and hence yields, of legumes were affected by disease and sweetclover weevil in one year, while in the second year good stands of all seedings were obtained. Total dry matter yields (tops plus roots) of Ladino and medium red clover in 1951 were about one and a half tons per acre, while alfalfas and sweetclovers yielded one-half ton or less per acre. In 1952, Madrid sweetclover yielded two and a half tons dry matter per acre, alfalfas about two tons, Ladino clover one and a half tons, and red clover between one and one and a half tons per acre. Hubam sweetclover yields were low in both years as a result of the annual growth habit of the species and because plots were harvested after partial leaf loss had occurred. Grimm and the strain of southern-grown common alfalfa were not significantly different in either dry matter or nitrogen yields. Exploratory experiments indicated that some strains of southern alfalfas vary in their yielding ability. Mammoth red clover yield was half that of medium red clover.

Nitrogen percentage of legume tops or roots did not vary significantly among species. Nitrogen yields, however, varied widely among legumes because of the wide differences in dry matter yields. When good stands were obtained, Madrid sweetclover yielded 135 to 150 pounds of nitrogen per acre, the alfalfas yielded between 60 and 120 pounds, Ladino clover between 50 and 110, and medium red clover between 35 and 80 pounds of nitrogen per acre in tops and roots. The differences found within legumes were due to the effects of both location and season.

¹Doctoral thesis no. 1585, submitted July 16, 1954. Chairman of Committee, I. J. Johnson, Department of Agronomy.

²B.S., University of Wisconsin, Madison, Wisc., 1949. M.S., Cornell University, Ithaca New York, 1951. Graduate Assistant.

A correlation of .976 was obtained between total dry matter yield and total nitrogen yield for all legumes at all locations and years. The correlation for all legumes between dry matter yield of tops (cut at the crown) and total nitrogen yield was .036. The latter relationship between top growth and total nitrogen yield lends confidence to the possible evaluation of legumes in terms of top yields alone.

Madrid sweetclover root yields were nearly equal to the top yields. Alfalfa top-root ratios were slightly higher than those for biennial sweetclover. Red clover top-root ratios were about 3.5 to 4.5, whereas those for Ladino clover were slightly higher. The top-root ratios for nitrogen yields were usually higher than corresponding ratios for dry matter yields, indicating the somewhat higher nitrogen contents of tops.

Mowing in midsummer, as indicated by data obtained at one location and in one season, drastically reduced fall top and root yields of the sweetclovers. This close clipping resulted in increased yields of the other four legumes.

Exploratory studies of a number of other legumes revealed that some species other than those included in the major study, such as Korean lespedeza, crimson clover, and hairy vetch, merit further investigation with respect to their value as green manure crops in Iowa.

Corn responded to both inorganic nitrogen applications and leguminous green manure treatments at three of the four locations in both years. The location where no yield response was obtained in either year had check yields of over 102 bushels of corn per acre. Corn yields following green manure treatments were, in general, proportional to the total nitrogen content of the legumes, and hence to their total growth. At some locations, no direct relationship between ammonium nitrate and legume treatments could be established with respect to efficiency of nitrogen source. However, when all corn yield responses were considered simultaneously, it was concluded that leguminous nitrogen was between 65 and 85 per cent as efficient as ammonium nitrate nitrogen in increasing corn yield.

Nitrogen percentage of corn leaves within each location and season was directly related to corn yield. Cob yields closely followed those of shelled corn. Only minor differences occurred among treatments in shelling percentage.

Additional studies were conducted with different rates of application of freshly-cut and other organic materials applied in early spring onto a single corn field. Freshly-cut alfalfa tops were more efficient in increasing corn yields than equivalent rates of application of freshly-cut red clover tops of slightly higher nitrogen content. Alfalfa applications were less efficient than ammonium nitrate treatments. Low-nitrogen materials such as soybean straw resulted in no corn yield increases over check. Residual nitrogen effects from these treatments, measured the succeeding year with an indicator crop of oats, were nonsignificant.

Availability of green manure nitrogen, as determined from the comparative yield responses to legume green manures and total nitrogen immobilization in corn, was estimated to range between one-third and two-thirds of that contained in the legume.

A brief consideration of the economic aspects of legume green manure utilization as compared to inorganic fertilizer as a source of nitrogen for corn in Iowa emphasized the relatively low cost of leguminous nitrogen.

A seeding mixture consisting of yellow-flowered biennial sweetclover, southern common alfalfa, medium red clover, and Ladino clover, was suggested for green manure purposes in Iowa.

ASSIGNMENT OF TRANSITION MULTIPOLE ORDERS FROM L SUBSHELL INTERNAL CONVERSION COEFFICIENT RATIOS¹

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Internal conversion ratios of the L subshells constitute a new method of determining multipole orders and type of transitions involving different states of the same nuclei. Some theoretical estimates of what these ratios should be for E1, E2, and M1 radiation already exist. The problem considered in this investigation was that of making transition assignments on the basis of a comparison between theoretical and experimental L subshell conversion ratios.

A 180° variable field spectrometer set for very high resolution was used. This spectrometer was unique in the method used for measuring and monitoring the magnetic field. A 200 to 5000 volt electron beam was focused by the uniform field into a semi-circle and detected by two adjacent carbon plates connected to a balanced electrometer. For a predetermined accelerating voltage, the field was adjusted so as to maintain an equal current to each of the two plates.

The radioactive sources were obtained by irradiation of the natural element in the Argonne CP-5 pile. The very high neutron flux, 1.5×10^{13} cm²/sec., gave sources of very high specific activity. These sources were deposited on thin Nylon films and formed into a filament about 0.2 mm wide.

Using a 0.1 mg/cm² source of Lu¹⁷⁷, it was found that $L_I/L_{II}/L_{III}/M = < 0.05/1.14 \pm 0.02/1.00/0.62 \pm 0.02$ for the 112.0 kev transition. This is in substantial agreement with the best theoretical estimates of $L_I/L_{II}/L_{III} = 0.11 \pm 0.03/1.14 \pm 0.03/1.00$ for E2 transitions. An E2 assignment agrees with that made by other investigators on the basis of angular correlation and the K conversion coefficient, and the K/L ratio.

In conjunction with the data above, gamma-beta coincidence spectra and the total beta spectrum were obtained using a 0.003 mg/cm² Lu¹⁷⁷ source in the intermediate image spectrometer. The two lower energy gammas were assigned energies of 112.0 \pm 0.2 kev and 208.7 \pm 1.4 kev respectively. The K/L/M/ratio of the 112.0 kev transition was determined as $0.64 \pm 0.02/1.00/0.28 \pm 0.01$. Although the K/L ratio was somewhat high compared to the currently used empirical curve for E2 transitions, there is evidence that indicates this empirical curve is probably low.

Confirmation of the E1 assignment to the 208.7 kev transition was obtained from its K conversion coefficient, $\alpha_K = 0.041 \pm 0.010$.

End point energies of the three beta groups were determined to be 180 \pm 2 kev, 388 \pm 3 kev, and 507 \pm 2 kev. No departures from a straight line were noted in any of the Kurie plots for the three beta groups. The energetics of the system of beta and gamma is quite consistent except that the 507 kev is a bit high. Log₁₀ ft values for the three beta transitions in order of increasing end point energy were 6.31, 6.94, and 6.80, respectively; these are all in the range classified as first-forbidden.

On the basis of the shell model prediction of p_{1/2} ground state for Hf¹⁷⁷, the E2 character of the 112.0 kev transition, and the first-forbiddenness of the two high energy beta transitions, a d_{3/2} level is assigned to the ground state of Lu¹⁷⁷ and an f_{5/2} level to the first excited state of Hf¹⁷⁷. The previous E1 assignment to the 208.7 kev transition makes the second excited state of Hf¹⁷⁷ an even parity level. Only an i_{3/2} even parity level is permitted by the shell model, but this has too high a spin value. Also, the low energy beta transition would have to be allowed, whereas it was found to be first-forbidden. On the other hand, granted that the low energy beta transition is truly first-forbidden, it follows that the second excited state of Hf¹⁷⁷ must be an odd parity level, probably p_{3/2}. In turn the 208.7 kev transition would have to be M1; this assignment disagrees with the assignment on the basis of α_K .

L subshell conversion ratios were also determined for the Tb¹⁶⁰ 85.1 kev transition. Statistics were poor because of a higher than usual background. Source scattering was also more evident because of the lower transition energy and the thicker source, 0.2 to 0.5 mg/cm². However, the conversion ratios were computed by a method wherein scattering was not too important. Other investigators using different methods have

¹Doctoral thesis no. 1599, submitted September 16, 1954. Chairman of Committee, E.N. Jensen, Department of Physics.

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established this transition as E2. The experimentally determined conversion ratios $L_I/L_{II}/L_{III}/M = 0.61 \pm 0.1/0.87 \pm 0.06/1.00/0.94 \pm 0.07$ agree best with the theoretical ratios for E2 transitions $L_I/L_{II}/L_{III} = 0.3 \pm 0.1/0.95 \pm 0.02/1.00$. The slight discrepancy in the ratio L_I/L_{III} may become more compatible when theoretical results including screening are available.

A GENETIC ANALYSIS OF YIELD IN UPLAND COTTON
(*GOSSYPIMUM HIRSUTUM* L.)¹

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The discriminant function approach was applied to the problem of selecting for yield in cotton. Data were obtained from an F_2 population derived from a cross between strains of the varieties Hartsville and Acala and from the two parental strains. Data were collected on thirteen variables which were obtained by subdividing yield into component subtraits in two alternative ways. Selection indexes were then constructed from various sets of subtraits, selected by level of subdivision, there being fourteen such indexes.

The genetic advance expected from the use of each index was used as the criterion of comparison of the indexes. No difference was detectable between those indexes derived from the two alternative systems of subdivision. Neither was any trend evident in the efficiency of the indexes obtained at successive levels of subdivision. The indexes, however, did tend to be more efficient selection criteria than did yield itself, having a mean efficiency (relative to direct selection for yield) of 250 per cent. The variability of the predicted performance values of the fourteen indexes was high, however, making an objective choice among them impossible, due to the lack of a measure of the standard error of these values.

For three of the indexes, the formula used to evaluate the expected genetic advance yielded an imaginary number. It was concluded that though biologically meaningless, such a result was computationally possible due to errors of estimation, in much the same way that negative estimates of variance components are possible. Thus, when the quantity $\sum b_i g_{iY}$ (where b_i is the multiple regression coefficient associated in the index with X_i , and g_{iY} is the genetic covariance of X_i with yield), which is of the nature of a sum of squares due to regression, takes on a negative value, it must be interpreted as an error deviation from zero. In such a situation the expected genetic advance therefore must also be interpreted as zero.

The heritabilities of the several subtraits were examined and in general were found to progressively increase at successive levels of subdivision. This was considered to be in agreement with the assumption of an additive genetic model for yield.

¹Doctoral thesis no. 1637, submitted March 7, 1955. Chairman of Committee, J. G. O'Mara, Department of Genetics.

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SUGAR BEET DISEASES AND THEIR CONTROL¹NORMAN R. GERHOLD²

Department of Botany and Plant Pathology

Tests were conducted in the laboratory, greenhouse, and in the field to show the effect of seed and soil treatments on the control of pre- and post-emergence damping-off of sugar beets incited by five isolates of *Rhizoctonia solani* and one isolate of *Pythium ultimum*. Different varieties of sugar beets were evaluated in the field for their resistance or susceptibility to *Fusarium oxysporum* f. *betae*.

Three separate strains of *Rhizoctonia solani* were identified on the basis of pathogenicity, cultural characteristics, and rate of growth at different temperatures. When subjected to various chemical compounds, there appeared to be no differences in resistance of the three strains to the chemical compounds employed. However, isolate No. 1 was more sensitive to Maneb and Thiram, at all concentrations, than to either Captan or Zineb. Maneb at 100 ppm was found to be effective in inhibiting mycelial growth of *Rhizoctonia* and *Pythium* when incorporated into warm potato dextrose agar and inoculated with small agar discs removed from five-day-old cultures.

Maneb was evaluated as a seed- and soil-treatment fungicide in infested and non-infested soil in the laboratory. The results showed that a Maneb-vermiculite mixture applied to the soil at 100 ppm was more effective in controlling post-emergence damping-off than seed treatment. Maneb as a seed treatment, 8 ounces per 100 pounds of seed, controlled pre-emergence damping-off very effectively in laboratory and greenhouse studies. There appeared to be a general trend for seedlings growing in *Rhizoctonia*-infested soil to have a higher degree of post-emergence damping-off than in *Pythium*-infested soil, although the differences in many cases were small.

Maneb was evaluated as a seed- and soil-treatment fungicide at different depths of planting in soil artificially infested with *Pythium ultimum*. There were no apparent differences in the amount of pre- and post-emergence damping-off between seed and soil treatment when seed was planted 1/4 inch deep. At depths of 1/2, 1, and 1 1/2 inches, soil treatment was more effective in controlling pre- and post-emergence damping-off than seed treatment.

Seed- and soil-treatment fungicides were evaluated by different laboratory testing methods against *Rhizoctonia* and *Pythium*. The most satisfactory laboratory test was found to be the incorporation of fungicides into warm potato dextrose agar and then inoculation with small agar discs. Dosage response in the laboratory tests was in close agreement with greenhouse and field results.

Applications of fungicides into the row at the time of planting with a modified hand planter (Planet Jr.) showed that Thiram and Zineb at 4 pounds per acre significantly increased the stand of sugar beet seedlings over the nontreated check. Significant differences were not obtained by the application of a 10 per cent Thiram dust into the row at the time of planting with a four-row crop duster.

Copper sulfate, at 25 pounds per acre, applied into the irrigation water was not effective in controlling *Fusarium* yellows of sugar beets. Under extreme epiphytotic conditions, Variety G. W. 359 was found to be the most resistant commercial variety tested when grown in a field naturally infested with *Fusarium oxysporum* f. *betae*. Selections were made from resistant and susceptible beet varieties. It was shown that where the frequency of resistant beets was low in a variety, one generation of selection makes a great improvement. Variety B 626 was highest in acre yields of beets and in content, but not significantly higher than its parent C 359 or B 589. All three varieties were significantly higher than B 525.

Soil-treatment fungicides were applied by a Milton drill modified to use materials either as dry powders or as spray mixtures. Field tests conducted in 1954 showed that Maneb-treated seed plus the application of a Maneb-vermiculite mixture into the soil at time of planting significantly increased the stand of sugar beet seedlings over the nontreated check. Maneb as a soil treatment alone showed significance over the nontreated check at the 5 per cent level, but not at the 1 per cent level. Cultivation had little, if any, effect on the number of surviving seedlings.

¹Doctoral thesis no. 1663, submitted May 31, 1955. Chairman of Committee, Charles S. Reddy, Department of Botany and Plant Pathology.

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ECONOMIC ASPECTS OF IRRIGATION IN THE WESTERN CORNBELT FRINGE
WITH SPECIAL REFERENCE TO THE PROPOSED SARGENT
RECLAMATION PROJECT IN CENTRAL NEBRASKA¹

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The Problem

Few agricultural areas in the United States have known more sharp and frequent alterations between optimism and distress and despair than the western edge of the Cornbelt and adjoining lands where instability of prices for farm products is compounded with the vagaries of fluctuating rainfall about a mean that is often barely adequate for crop production. The problem is further aggravated by the small size of many farm enterprises, established when the region was first settled at a time when the nature of the agricultural potential of the western fringe of the Cornbelt was not understood. Added uncertainty, due to lack of security of tenure, and exploitive use of soil resources have been accompanying phenomena.

Objectives

Insofar as it is possible to consider separately any one of the remedial measures proposed for the Cornbelt Fringe, the study summarized here deals with the economic potential of gravity irrigation by surface diversion. The problem was analyzed from the related viewpoints of 1) a farmer who owns the unit he operates, 2) a tenant and landlord, and 3) the public interest.

Lease terms anticipated under irrigation were examined for conduciveness to maximization of profits from the entire farm business and an attempt was made to suggest improvements in anticipated lease terms. It was also attempted to anticipate the major problems likely to arise during the process of transition from dryland to irrigation.

Area of Study

The area of study is the Sargent Project, planned by the U.S. Bureau of Reclamation and located at the western edge of the Cornbelt in a region receiving sufficient rainfall for dryland crop production.

The conceptual framework and the research techniques employed are of general applicability. It is estimated that the general conclusions reached for the Sargent Area can be used as a guide for potential irrigation projects on gently sloping silty to sandy loams, located in long but narrow river valleys, in all but the northern portion of the western fringe of the Cornbelt. Many small federal reclamation projects have been proposed for that region. Further testing will be required for each of these proposed developments as a basis for making specific recommendations.

The Findings

Under existing provisions for repayment of the federal outlay for irrigation works and anticipated irrigation lease terms, owner operators, tenants, and landlords will experience substantial economic gains from the proposed irrigation projects. A detailed analysis was made of four family farms operated at a level of management judged to be within the capability of most farmers in the area. Each of the four units is representative of a major type of farm organization anticipated under irrigation. For the four farms analyzed, annual income to an owner operator is estimated to rise from 2,100 to 3,700 dollars or 52 to 187 per cent over dryland income. From the limited evidence available it was tentatively concluded that irrigation is not likely to stabilize farm income in periods of favorable rainfall although irrigation will provide valuable protection against drouth.

¹Doctoral thesis no. 1578, submitted July 15, 1954. Chairman of Committee, John F. Timmons, Department of Economics and Sociology.

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When the change to irrigation is associated with an increase in the livestock enterprise, the increase in income will be greater for a crop share tenant than a crop share landlord. The reverse is true if irrigation brings a decrease in livestock enterprise. With a livestock share lease, the gains from irrigation are more nearly equally divided between tenant and landlord.

Owner operators and landlords are likely to find irrigation a more profitable means of increasing their business than adding to the dryland crop acreage. Tenants, by contrast, are likely to find expanded dryland farming more profitable than irrigation. While average annual costs of gravity and well irrigation are approximately equal for owner operators, it appears, from limited evidence, that gravity irrigation is less costly than well irrigation for landlords while the reverse is true of tenants.

Anticipated crop and livestock share leasing arrangements are likely to present certain obstacles to maximization of profits from the entire farm business. However, it is not expected that leasing arrangements will present a major obstacle to profitable farming in the study area. The possible disadvantages of tenancy must be weighed against the advantages of that form of land tenure which permits sharing of the capital requirements and risks of irrigation farming and facilitates combination of the complementary productive resources of tenant and landlord.

While suitable lease terms will have to be worked out on an individual farm basis, the following two general improvements are suggested for crop share leases: 1) Landlords should receive a cash rental for buildings. Since landlords are expected to receive a favorable return on their investment under anticipated crop share leases without building rental, some further adjustment should be made in lease terms so as to offset the income transfer to the landlord. 2) Where most of the forage is sold, it is suggested that the landlord's share of the irrigated forage be reduced from one-half to two fifths to make it equal to the landlord's share of irrigated grain crops anticipated under irrigation.

Most farm operators and landlords will find it more profitable to prepare all their irrigable land prior to the year that irrigation water becomes available than to follow the customary method of gradual land preparation over an extended period. The sizable assets held by farm operators and land owners will provide a favorable financial basis for meeting the capital outlays required for irrigation development. However, there is need to adapt the lending of local credit agencies to the requirements of irrigation loans.

For many small farms in the study area, irrigation will be only one step towards increasing the farm enterprise to an adequate family farm. Further increase in the productive resources of these small farms will be needed to bring them to family size.

Because of the value judgments involved, and lack of comprehensive criteria, no final conclusion can be drawn regarding the feasibility of the proposed Sargent Reclamation project as a public investment. However, the evidence assembled regarding: 1) the low financial returns on the total investment, 2) the small proportion of the public outlay that will be repaid by direct beneficiaries, and 3) the existence of less costly alternative measures for the area, consisting of an integrated program of well irrigation, improved dryland farming on an enlarged scale and crop insurance, does suggest a reappraisal of the project and points to the need for additional research to improve the standards and administrative procedures in formulation of public resource programs.

OPTIMUM LIVESTOCK PRODUCTION UNDER VARYING RESOURCE
AND PRICE-COST SITUATIONS IN NORTHEAST IOWA --
AN APPLICATION OF LINEAR PROGRAMMING¹

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The objectives of the present study are:

1. To determine, given the cropping system on an individual farm, the combination of livestock enterprises which best utilize the available feed, consistent with maximum profit.
2. To determine the effect of changing resource and price situations on the optimum livestock combination.
3. To make an application of the linear programming technique and logic to farm planning.

The farm selected for the analysis was from an area generally designated as the northeastern dairy area of Iowa. Carrington Clyde forms the predominant soil type. The farm size assumed was a 160-acre unit. Only feeds grown on the farm were assumed as available for livestock production. Data for the crop rotation used in the analysis were based on existing farm practices as well as agronomic experiments carried on in the area concerned.

Many feasible or possible livestock enterprises were considered in setting up alternatives from an optimum livestock program which was selected by linear programming methods. The feasible livestock enterprises included: 15 competitive dairy enterprises; 6 competitive swine enterprises; 3 competitive poultry enterprises; 1 competitive beef enterprise; 15 supplementary dairy enterprises; and 3 supplementary poultry enterprises.

Given the many feasible livestock enterprises, several changing price and resource situations were considered. Each change in relative prices or available resources was designated as a new situation. For each situation, the linear programming technique was applied in order to select from the many feasible enterprises the optimum combination of livestock enterprises. In all, 41 different situations were programmed.

It was found that changes in the quantity of available labor, capital, and hay had very significant effects on the optimum combination of livestock enterprises. For example, an increase in quantity of available hay caused the high grain consuming enterprises to contract while those enterprises depending on a high forage ration, such as the dairy cows, were considerably expanded. Such a shift in the optimum livestock program caused the ratio of grain to hay in the livestock rations to more nearly coincide with the grain-hay ratio of the crop rotation. In effect, this meant a meaningful integration of livestock production with the prevailing cropping program. Changes in the quantity of available labor and capital likewise caused contractions and expansions of certain types of livestock enterprises consistent with resource limitations and profit maximization.

Changes in relative prices on the other hand exerted very little effect on the reallocation of resources among the various alternative livestock enterprises. While further studies are needed at this point, it would appear from the present analysis that resource structure rather than changing price ratios were most important in the determination of an optimum livestock program. If the present results have general empirical validity, it might be concluded that farmers are not as responsive to changing prices as is sometimes indicated.

The linear programming technique promises to be a very useful addition to the list of theoretical and empirical tools of farm management economics. It is especially important in its application to the planning and management of the individual farm. It is well adapted to individual farm planning because it recognizes the characteristics unique to a particular farm. In the more simple cases, the budgeting technique may well prove superior to linear programming in finding an optimum plan for the farm. For the more complex cases, however, linear programming proves more efficient. Linear programming is well adapted to the selection of an optimum plan from a relatively complex pattern of production possibilities.

¹Doctoral thesis no. 1620, submitted December 10, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

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Linear programming is essentially an integrating tool of farm management. It does not provide the basic input-output data of the farm; rather, it utilizes these data. The basic input-output data must be provided from pure production function research, farm accounts, survey records, and other traditional means of acquiring basic farm production data.

However, linear programming is not without some disadvantages. It still requires sound judgment and an intimate knowledge of the empirical conditions to which it is applied. The assumptions of linearity, constant coefficients, constant returns to scale, and complete resource divisibility are not necessarily valid assumptions under many existing farm conditions. Linear programming is a powerful economic tool in farm management research but it must be used with discretion.

ECONOMIC DEVELOPMENT THROUGH AGRARIAN REFORM¹

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During the first half of this century, economically underdeveloped nations in the world have become increasingly desirous of initiating economic development. The need for economic development is indicated by the fact that 39 per cent of the world's population had a per capita income of less than 60 United States dollars in 1948. Agriculture is important to these nations as a source of national wealth. In Asia in 1948, 70 per cent of the population was agricultural; in Africa, 74 per cent; in South America, 62 per cent. These people desire and are working toward economic development. At the same time professional economists have worked to understand more of the nature of the process of economic development.

There is, unfortunately, no established theory of economic development, although many able economists are working to gain a fuller grasp of the process of economic development. They are re-examining some of the basic concepts of economic theory, and attempting to relax such basic assumptions as those of the "economic man," entrepreneurial ability, perfect information, adjustment lags, external economies, and institutional impediments. They are coming to realize that population must be viewed as a resource. They are coming to recognize that man's ability to use the materials of nature constitutes the real foundation of natural resources. From this view, the problem of economic development becomes one of how to organize existing human and material resources.

Economic development can be meaningfully defined to include an increased per capita production and consumption of goods and services and more widespread distribution of consumption. Agrarian reform is taken to mean changes in agrarian institutions consciously undertaken to improve the efficiency of agricultural procedures as a means of achieving both economic and noneconomic objectives.

The problem of the research worker in social sciences is to abstract out of the thought and actions of peoples goals of human endeavor and to determine means of reaching these ends. The basic ends of human society include life, opportunity, and liberty. Working from these in the framework of a continuum of means and ends, various ends-in-view may be delimited, conflicts between ends-in-view pointed out, and means to reach specific ends-in-view determined.

Within the means-ends continuum, economic development is one of the ends-in-view. Agrarian development is a less basic end-in-view, and agrarian reforms constitute the means by which to achieve agrarian development. It may thus be seen that agrarian reforms may only be properly considered in the context of their effect on over-all economic development.

Necessary conditions for economic development are as follows: 1) a subsistence norm embracing the concept of a minimum human level of living which the society will tolerate, and below which the society will make income transfers to individuals;

¹Doctoral thesis no. 1657, submitted May 24, 1955. Chairman of Committee, John F. Timmons, Department of Economics and Sociology.

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2) factor rewards in accordance with productivity; 3) increased efficiency of labor; 4) increased efficiency of capital; 5) increased efficiency through adjustments of economic institutions; 6) increased efficiency through adjustments in social institutions; and 7) increased efficiency through dissemination of information.

Within the framework of the necessary conditions for economic development, the following remedial alternatives to overcome institutional impediments to agrarian and economic development in underdeveloped countries were suggested: 1) lessening temporal uncertainty arising from conditions of tenure, the principal remedial alternative being to lengthen cultivator's planning horizons through (a) increasing security of tenant expectations, (b) owner-occupiership, or (c) group tenure; 2) reducing high fixed costs to the operator, principally through rent control programs which limit rent payments; 3) reducing noncontiguous tracts through consolidation programs; 4) overcoming undersized holdings by increasing productivity or through group tenure; 5) reducing underemployment of land arising from the pattern of ownership by taxation to encourage more intensive use or through transferring cultivation rights; 6) reducing title insecurity principally through some means of registering title; 7) reducing high fixed costs of operating credit by credit co-operatives, supervised credit, etc.; 8) reducing fixed costs to the owner by providing long-term credit suited to cultivator's repayment abilities at suitable rates; 9) providing legal machinery to make redress of grievances a practical possibility for small cultivators; 10) disseminating information to enable cultivators to improve their productivity; and 11) reducing occupational immobility by encouraging cottage industries, providing vocational training, and encouraging balanced economic development.

The postwar agrarian reform program in Japan, analyzed to determine how the institutional impediments discussed above were overcome and to assess the effectiveness of the program, was found to have accomplished the object of reducing temporal uncertainty through promotion of owner-occupiership, and to have been moderately successful in making credit facilities available to small owners. There are indications large landlords may be able to regain positions of influence in the villages, but the problem has not become serious yet.

It was suggested that agrarian reform as a means of promoting economic development could well play a more important part in United States foreign policy than it has to the present time. Finally, it was suggested there is a need for further research relating to how to overcome institutional impediments to agrarian development, particularly the effects of various agrarian reforms on economic development, and research on how the United States can best help underdeveloped countries carry out agrarian reform programs.

BIOLOGICAL STUDY OF THE EUROPEAN CORN BORER IN BOONE COUNTRY, IOWA¹

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This study consisted of a systematic survey of the European corn borer in 176 (1950) or 88 (1951, 1952, 1953) corn fields in Boone County, Iowa. The corn fields were selected on a series of concentric circles covering the county. Within each field 20 corn plants were selected and identified for future observations. Each field was visited twice weekly during the growing season and observations made on the number of corn borer eggs present, the fate of these eggs, extended height of the corn plant, and predators present on the plants.

Records were kept of the seasonal development of the borer by making dissections of corn plants at regular intervals and recording the stage of development for a given number of borers. These dissections were made in various fields distributed over the county.

¹Doctoral thesis no. 1609, submitted December 2, 1954. Chairman of Committee, Tom A. Brindley, Department of Zoology and Entomology.

²B.S., Eastern Illinois State College, Charleston, Ill., 1949. M.S., Iowa State College, Ames, Iowa, 1951. Associate, Agricultural Experiment Station.

The natural mortality of the corn borer in this area was followed by making population counts in the spring, summer, and fall. The spring counts were made in the previous year's corn fields and were made on an area basis. The summer counts were made by dissecting half of the plants (10 per field) in each of the observation fields. The remaining ten plants in each field were observed during the remainder of the season and finally dissected in the fall to get a measure of corn borer abundance and also an estimate of borer survival.

Corn borer larvae collected in the field were isolated and "reared" at the Ankeny Laboratory to get information on the effectiveness of both native and introduced parasites.

1950.

The spring population survey of the overwintering borers made in 44 of the previous year's corn fields, showed an average of 5,200 borers per acre.

Only 7.1 per cent of the first brood pupated and emerged to form a second brood which was of little economic importance. This was due, partially at least, to the abnormally cool season. During first brood oviposition the average rate of corn growth was 1.3 inches per day.

First brood survival based on total number of eggs laid and the live borers recovered at the time of mid-summer dissections was 2.6 per cent. The borer population following the first generation oviposition averaged 145 borers per 100 stalks or an estimated 17,400 borers per acre. The fall borer population as determined by dissection from September 18 to 29 averaged 110 borers per 100 stalks or an estimated 13,200 borers per acre.

Corn borers taken to the laboratory and reared from dissections throughout the year revealed a very low incidence of parasites, 0.9 per cent of the borers from the spring dissections, 0.5 from the summer dissections and 0.4 per cent from fall collections were parasitized.

1951.

The spring population survey was made during the pupation period in 44 of the 1950 observation fields and showed an average of 1,300 borers per acre.

The spring moth flight started on May 28 and ended on July 26, with a peak on June 17. The first eggs were observed on June 13, oviposition reached a peak on June 27, and was complete by July 20. There was an average of 21.5 egg masses per 100 plants.

First brood survival based on total and hatched eggs observed and live borers at the time of summer dissections was 7.2 per cent and 10.3 per cent, respectively. The summer borer population averaged 22.1 borers per 100 plants or 2,500 borers per acre.

Summer moth flight occurred during the period from July 29 to September 29, with a peak catch on August 29. Oviposition for the second generation was first observed on August 11 and the last eggs recorded on September 10. The peak of oviposition came on August 27. There was an average of 29.0 egg masses per 100 plants during this period.

Fall dissections revealed an average of 78.1 borers per 100 plants or an estimated 9,372 borers per acre. Based on the total number of eggs observed, borer survival for the season averaged 8.9 per cent. The parasite population remained low with only 2.7 per cent of all the forms isolated being parasitized.

1952.

An average of 390 borers per acre was found in the spring population survey conducted May 27 to June 3 in 44 of the 1951 observation fields. Winter mortality amounted to 34.8 per cent.

The spring moth flight began on June 2 and ended on July 9, with a peak on June 12. First brood oviposition was first observed on June 10 and it reached a peak on June 16. First brood oviposition was at an average of 8.5 egg masses per 100 plants, of which 74.3 per cent hatched.

Summer dissections produced an average of 5.9 borers per 100 plants with 18.2 per cent of the plants being infested. The estimated number of borers per acre was 708, which is the lowest level of the population recorded during the four-year study. The survival of first generation borers was 4.1 per cent based on total eggs and 5.3 per cent based on hatched eggs.

Summer moth flights began on July 18 and continued through September 13, with a

peak on August 10 and a similar peak on August 13. Second brood oviposition was first observed on July 25 and by August 29 it was virtually completed although one egg mass was found on September 2. Oviposition reached a low peak on August 5; however, mid-oviposition was not until August 9, two weeks earlier than in 1951. Oviposition averaged 32.0 egg masses per 100 plants, 71.3 per cent of which hatched.

Fall dissections indicated an average of 122 borers per 100 plants, or an average of 14,400 borers per acre. Borer survival for the season was 17.1 per cent using total eggs and 23.9 per cent using hatched eggs. This is an unusually high per cent survival.

Borers taken to the laboratory were examined for the microsporidian parasite; however, there was a low incidence of *Perezia pyraustae* Paillot, in Boone County (5.1 per cent).

1953.

The spring population survey was made May 19-23 and indicated an average of 1,120 corn borers per acre which is a considerable increase over 1952. Winter mortality averaged 16.8 per cent in the area.

Spring moth flight started on June 4 and continued until July 8, but the peak was reached on June 14. Oviposition was first recorded on June 8, reached a peak on June 23, and by July 10 it was complete. First brood oviposition averaged 36.9 egg masses per 100 plants, which was the highest since the spring of 1950.

First brood survival was 8.1 per cent based on total eggs or 12.5 per cent when using only hatched eggs. The 1953 survival for first generation borers was the highest recorded during the four years. The summer borer population averaged 42.8 borers per 100 plants or an average of 5,136 borers per acre.

First summer brood moths were collected in the light traps on July 10, the peak flight was August 10, and the last moths were caught on September 7. Oviposition of the summer brood began on July 2, continued until September 7, and reached a peak on August 4. During this period a total of 1,221 egg masses were observed or an average of 138.7 egg masses per 100 plants. This is the largest second brood since the fall of 1949.

Fall dissection indicated an average of 271 borers per 100 plants or an average of 32,520 borers per acre. Borer survival for the season averaged 8.2 per cent using total number of eggs or 12.9 per cent using the eggs which hatched. The parasite population was extremely low with only 0.9 per cent of the borers being parasitized.

SEQUENCES OF AMINO ACID RESIDUES IN BACITRACIN¹

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Commercial bacitracin was subjected to stepwise degradation by alternate blocking of N-terminal residues with alkaline phenyl isothiocyanate and removal of the thus formed phenylthiocarbamyl terminal residues as 3-phenyl-2-thiohydantoin with dry dioxane-hydrogen chloride. In two experiments, samples were given 0 to 4 and 0 to 6 such treatments. Microbiological assay of the hydrolyzed treated peptides showed no significant decrements in their amino acid content with successive treatments, indicating that no N-terminal residue is present. This suggests that the major peptide of bacitracin, bacitracin A, is of a cyclic nature.

Blocking reactions carried out with ammonium thiocyanate or phenyl isothiocyanate in acetic anhydride failed to remove any C-terminal residue from the major peptide of bacitracin, as determined by microbiological assay of acid hydrolysates of the treated material. A small proportion of C-histidine which was found is probably associated with a minor peptide.

¹Doctoral thesis no. 1579, submitted July 15, 1954. Chairman of Committee, Sidney W. Fox, Department of Chemistry.

²B.A., Reed College, Portland Oregon, 1950. Research Fellow, Department of Chemistry and Industrial Science Research Institute.

Samples of bacitracin were partially hydrolyzed with 1:1 10 N hydrochloric acid-glacial acetic acid at 37° for 1, 2, 4, and 8 days. Aliquots of the partial hydrolysates were given one or two aminoid blocking treatments, a single carboxoid blocking treatment with ammonium thiocyanate, or no blocking treatment. Microbiological assay of complete hydrolysates of these samples showed considerable variation in the rate of hydrolysis of different peptide bonds. Bonds involving the carboxyl group of L-isoleucine or the α -amino groups of lysine or L-aspartic acid were not detectably hydrolyzed in 8 days. N-Penultimate histidine appeared in a very small proportion in 8 days, indicating that a peptide bond one residue removed from the amino group of histidine was only slightly hydrolyzed. Bonds involving lysine or leucine carboxyl groups or an L-isoleucine amino group were 15 to 30 per cent hydrolyzed in 8 days. N-penultimate lysine and L-isoleucine appeared in amounts equivalent to 27 per cent of the total of each of these residues. The residues which appeared most rapidly were N-penultimate aspartic acid and C-histidine, 60 per cent and 58 per cent, respectively, in 8 days. No assays were carried out for cysteine or for those residues known to be of the D-configuration (glutamic acid, phenylalanine, and ornithine). The above findings were qualitatively confirmed by paper chromatography of untreated partial hydrolysates.

Several possible two-residue sequences are obtained on matching the rates of appearance of amino and carboxyl groups of assayable residues during partial hydrolysis, and from these, four partial sequences can be formulated for bacitracin:

1. -leu-iso-lys-x'-his-x''-asp-
2. -leu-iso-lys-x'-iso--his-x''-asp-
3. -leu-x-iso-lys-x'-his-x''-asp-
4. -leu-x-iso-lys-x'-iso--his-x''-asp-.

Sequence 4 agrees with part of the structure of bacitracin A, proposed by Craig, Hausmann, and Weisiger (1), in which x is D-glutamic acid, x' is D-ornithine, x'' is aspartic acid, and a D-phenylalanine residue joins isoleucine and histidine.

Bacitracin was desulfurized with Raney nickel and sequential residue blocking reactions were carried out on the product. Paper chromatographic analyses of acid hydrolysates of the treated peptides and alkaline hydrolysates of the extracted thiohydantoins and phenylthiohydantoins failed to indicate any residue sequences inasmuch as several N-termini and at least two C-termini were present following the Raney nickel hydrogenolysis. Leucine and/or isoleucine, glutamic acid, and an unidentified ninhydrin-positive substance appeared in the extract hydrolysates. A very small amount of alanine was also detected, indicating only partial reduction of the cysteine residue.

Bacitracin A was oxidized with performic acid in order to convert the cysteine to a cysteic acid residue. Moore-Stein analysis of an acid hydrolysate of the oxidation product on Dowex-50 columns detected only 0.6 residue of cysteic acid, the rest of the original cysteine residue being unaccounted for. Three residues of isoleucine were found, compared to two residues of L-isoleucine found in commercial bacitracin by microbiological assay, thus the third residue must be of the D-configuration. A single aminoid blocking treatment of the performic acid oxidation product removed less than one-half of a residue of isoleucine and caused no decrements in the other amino acids, as determined by Moore-Stein analysis, therefore the presence of N-isoleucine in bacitracin A remains in doubt.

A study of carboxoid blocking conditions on leucylvaline and benzoylleucylvaline with ammonium thiocyanate and phenyl isothiocyanate showed partial blocking of the aminoid residue by either reagent. Ammonium thiocyanate produced considerably more blocking of the carboxoid residue than did phenyl isothiocyanate, but still left about 30 per cent of the valine available to the assay organism, *Streptococcus faecalis*.

The aminoid blocking reaction with phenyl isothiocyanate almost quantitatively removed leucine and isoleucine added to samples of commercial bacitracin, as determined by microbiological assay with *Lactobacillus arabinosus* 17-5.

REFERENCE

1. Craig, L. C., W. Hausmann, and J. R. Weisiger. J. Am. Chem. Soc. 76:2839. 1954.

UNIDENTIFIED FACTORS STIMULATORY TO CELLULOSE
DIGESTION BY RUMEN MICROORGANISMS¹ORBIE GLEN HALL²

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This study was initiated to obtain more information concerning unidentified factors stimulatory to cellulose digestion by rumen microorganisms. In order to facilitate such studies, a more sensitive and convenient laboratory assay technique than those currently used was needed. One phase of this study consisted of the development of such a technique as well as a synthetic medium containing all the chemically defined nutrients known to be required by rumen microorganisms. Equally important phases of the study included: 1) determining if known B-vitamins or certain carbohydrates were the active unidentified stimulatory factors, 2) the development of a potent source of the factors which might be produced economically and in large quantities, 3) determining the significance of the association of unidentified cellulolytic stimulatory factors with materials rich in either protein or nonprotein nitrogen, and 4) determining the influence of certain sources of these cellulolytic factors upon body weight gains and feed consumption by lambs.

A technique employing washed suspensions of rumen microorganisms was developed for the study of factors influencing cellulose digestion *in vitro*. The technique consisted of separating the bacteria from strained rumen liquid by differential centrifugation. The bacterial cells were washed twice before being used to inoculate a chemically defined nutrient solution containing purified wood cellulose. When washed rumen microorganisms were suspended in 20 milliliters of a nutrient solution containing 0.5 per cent cellulose, approximately 40-60 per cent of the cellulose was digested during an incubation period of 24 hours. Conditions required for optimum cellulolytic activity, such as pH, concentration of the substrate, concentration of rumen bacteria, and the duration of incubation were determined.

The mineral and nitrogen requirements of rumen microorganisms for maximum cellulose digestion were determined by using the washed suspension technique. Among the 11 mineral elements tested, calcium, zinc, cobalt, and copper did not significantly increase microbial cellulose digestion. Levels of 5, 5, and 16 ppm of cobalt, copper, and zinc, respectively, inhibited cellulose digestion. The optimum ratio of sulfur to nitrogen required by rumen microorganisms was found to be in the range of 1:10 to 1:17.

Several of the B-vitamins were found to enhance cellulose digestion by rumen microorganisms when added individually to fermentation tubes. These vitamins were: pseudovitamin B₁₂, vitamin B₁₂, biotin, folic acid, pyridoxine, paraaminobenzoic acid, and riboflavin. A combination of vitamin B₁₂ and biotin stimulated microbial cellulose digestion more than did either of these vitamins alone. This combination of vitamins was equally as active as any other combination of vitamins studied. No single B-vitamin or combination of B-vitamins was found which increased microbial cellulose digestion to the same extent as did yeast extract.

Of the carbohydrates studied, xylose, arabinose, ribose, rhamnose, sorbose, and maltose stimulated cellulose digestion only slightly. High levels of many of these compounds depressed cellulose digestion by rumen microorganisms.

Fractionation studies of different types of yeast and yeast fermentation by-products showed that plasmolyzed torula yeast cream stimulated cellylose digestion *in vitro* by rumen microorganisms markedly. The plasmolysis apparently concentrated the active cellulolytic factors outside the yeast cells making them more accessible to rumen bacteria.

A partial acid hydrolyzate of feather meal was shown to be equally as active as autoclaved rumen liquid in stimulating cellulose digestion *in vitro* by rumen microorganisms. Partial acid hydrolyzates of casein, hair, soybean oil meal, gelatin, and drackett protein were also active. Untreated vitamin-free casein, feather meal, and completely hydrolyzed vitamin-free casein exhibited only slight, if any, activity.

The active factors in feather meal hydrolyzate were found to be relatively stable to heat and dialyzable. They were not removed from an acidified solution by steam

¹Doctoral thesis no. 1662, submitted May 27, 1955. Chairman of Committee, Wise Burroughs, Department of Animal Husbandry.

²B.S., Berea College, Berea, Kentucky, 1951. M.S., University of Kentucky, Lexington, Ky., 1952. Graduate Assistant.

distillation or ether extraction. Some activity was removed from aqueous solution by repeated extraction with 70 per cent ethanol.

Additions of either *n*-valeric acid, *n*-caprioc acid, a mixture of *n*-valeric and isovaleric acids, or a steam distillate of acidified rumen liquid failed to stimulate cellulose digestion by rumen microorganisms under the conditions of these experiments. These results and those obtained from partial acid hydrolyzates of various protein materials suggest that water soluble peptides may be involved in rumen microbial cellulose digestion *in vitro*.

Two feeding experiments were conducted in which the effects of protein hydrolyzates and a press yeast liquor concentrate upon the body weight gains and feed consumption by lambs fed semi-purified rations were studied. Rate of gain and feed consumption were increased considerably in both experiments by these materials. Although the differences in gain and feed consumption were not statistically significant, the results of these experiments suggest that protein hydrolyzates and press yeast liquor contain factors which are needed by lambs for maximum performance. It was also found that a solution of yeast products, when given orally, restored appetites in lambs that had been off feed for periods of time ranging from 10-14 days. However, since no control lambs were used, more extensive studies are being conducted to confirm this observation.

PART I. MECHANISMS OF INHIBITED AIR OXIDATION OF OLEFINS.

PART II. REDUCTION OF NITRO COMPOUNDS WITH TITANIUM III.¹

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Part I.

The primary problem of this study was to determine the chemistry of substances which inhibit the air oxidation of an easily oxidizable hydrocarbon. The thermal decomposition of azo-bis-isobutyronitrile in the presence of oxygen was used as a chain initiator for the oxidation reaction. A careful semiquantitative study of the products of the reaction was instituted to establish the stoichiometry of the reactions of peroxy radicals with an inhibitor. Results were as follows:

1. An excellent yield of the oxidation product from the inhibitor *N,N'*-diphenyl-*p*-phenylenediamine was obtained and through ultraviolet spectra it was determined that *N,N'*-diphenyl-*p*-phenylenediimine was obtained in 90-96 per cent yield. From this, the stoichiometry of each of the inhibitor molecules for peroxy radicals was assigned as two. The efficiency of initiation by the initiator was thus determined also. This confirmed the results obtained from the isolation and semiquantitative determination of the dimer product formed by radicals (from the initiator) which did not react with oxygen to form the chain initiating peroxy radicals.

2. It was shown that an inhibitor with labile hydrogen does not always lose hydrogen as a principal course of reaction when attacked by peroxy radicals.

3. Studies of termination reactions of the uninhibited air oxidation of olefins proved unlikely to be rewarding because of the instability of the primary products.

4. An unsuccessful attempt was made to utilize air oxidation of triphenylmethylazobenzene during thermal decomposition as a means of preparing the unknown compounds diphenylperoxide or phenylhydroperoxide.

Part II.

An investigation was made to determine if a nitro compound could be reduced in the rate determining step by a one electron step or whether it must have two electrons to be reduced. It has been shown in this investigation:

1. That titanous ion, which can release only one electron per ion, exhibits first

¹Doctoral thesis no. 1628, submitted December 22, 1954. Chairman of Committee, George S. Hammond, Department of Chemistry.

²B.S., Southwest Missouri State College, Springfield, Mo., 1941. M.S., Brigham Young University, Provo, Utah, 1951. Graduate Assistant, Department of Chemistry and the Industrial Science Research Institute.

order kinetics in the reduction of nitro compounds. Therefore, a nitro compound may be reduced by a one electron transfer in the rate determining step.

2. It has further been shown that the reaction is bimolecular with respect to titanous ion and nitro compound.

3. Although it is easily observed that the rate of reaction decreases with increased hydrogen concentration, the exact dependence of the rate on hydrogen ion was not determined.

4. An unsuccessful attempt was made to discover the effect of changes in ionic strength upon the rate of the reaction.

GENETIC AND ENVIRONMENTAL RELATIONSHIPS OF COMPONENTS OF YIELD,
MATURITY, AND HEIGHT IN F_2 - F_3 SOYBEAN POPULATIONS¹

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The objective of this study was to aid in establishing the general pattern of inheritance of yield, maturity, and height in soybeans by the analysis of subcharacters.

The F_2 and F_3 generations of the three possible crosses among Adams, Korean, and Chief Selection were grown with the parents in 1952 and 1953, respectively. Data were recorded on a single-plant basis for seed yield and its component number of seeds, average seed weight, seeds per pod, total pods, pods on the main stem, and pods on the branches; maturity and its component days to first bloom and days from first bloom to maturity; height; and number of branches. All calculations were based on progeny means for the F_3 and individual plant data for the F_2 and parents.

Growth and yields were excellent in 1952 although abnormally delayed ripening of most plants of Adams and some plants in all other populations reduced the efficiency of evaluation of maturity and first bloom to maturity. In 1953, drouth hastened maturity and greatly reduced height and all yield components except seeds per pod, which was reduced very slightly.

The means for the segregating generations were, in general, intermediate to parental means. The only exception consistent in all crosses was seed yield which exceeded the higher parent. Coefficients of variability were generally lower when computed from F_3 progeny means than from F_2 plant data, but the differences were small enough for the two to be considered similar in magnitude. They were similar for the same character in the three crosses, but differed widely among characters in the same cross. The most variable characters were number of branches and pods on the branches. Maturity and its components were least variable.

Estimates of heritability, calculated as the regression of F_3 means on F_2 plant data, were consistent in all crosses. First bloom had the highest estimate although height, maturity, seed weight, and seeds per pod gave highly significant values, indicating that individual plant selection in early segregating generations should be effective for these characters. Lower but significant values were obtained for total pods, pods on the main stem, and number of seeds. The estimates were lowest for seed yield, pods on the branches, and first bloom to maturity.

Days to first bloom and first bloom to maturity showed high, positive correlations with maturity, but low or negative correlations with each other. Maturity, height, and yield were positively correlated in all crosses.

Although number of seeds showed a lower heritability than seed weight, it was highly correlated with yield whereas average seedweight was not. Total pods and pods on the main stem showed high correlations with number of seeds and yield. Standard partial regression coefficients indicated number of seeds to be about three times as important as seed weight in determining yield. Because of the lower variability of pods on the main stem and its strong association with number of seeds and yield, it would appear to offer more promise as a selection criterion than the other components of yield.

¹Doctoral thesis no. 1568, submitted June 25, 1954. Chairman of Committee, C.R. Weber, Department of Agronomy.

²B.Sc., University of Nebraska, Lincoln, Nebraska, 1942. M.S., Ibid., 1948.

Number of seeds was negatively correlated with seed weight, and number of pods was negatively associated with seeds per pod. These indicate competition among the developing seeds for the food manufactured in the plant.

The tendency for high genetic correlations to occur between characters with moderate to high heritabilities and to be explained by parental combinations of these characters prevailing in the F_2 and F_3 would suggest linkage, rather than pleiotropy, as the important factor in causing such associations. Rapid fixation of parental combinations of genes in a homozygous condition in self-pollinated species limits recombination. High genetic correlations due to linkage and to pleiotropy have different implications for plant breeders. The relative effects of these possible causes of genetic correlations should be evaluated experimentally.

FIXATION AND RELEASE OF AMMONIUM IN SOILS AND CERTAIN MINERALS¹

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This investigation was undertaken because an understanding of NH_4 fixation and release in soils may be of importance in making more efficient use of NH_4 fertilizers. and because certain properties of NH_4 make it a unique tool by which the mechanism of cation fixation may be studied. Attention was given only to the fixation of NH_4 ions by the clay minerals fraction of the soil and to related studies of K fixation.

In thermal studies of NH_4 saturated clay minerals, NH_4 continued to be gradually lost as the time of heating was increased. Thus, it appears to be impossible to distinguish between the different forms of NH_4 on the minerals by thermal methods. The different minerals started to lose their NH_4 at different temperatures indicating that this property might be useful in determining whether montmorillonite or vermiculite is present in an unknown sample. Bentonite, which fixed no NH_4 under moist conditions, fixed appreciable amounts of NH_4 when heated to higher temperatures. Differential thermal analysis showed exothermic peaks due to loss of fixed NH_4 from bentonite but not from vermiculite.

The presence of small amounts of fixable ions in alkaline solutions or in solutions of salts and acids retarded or prevented the release of fixed NH_4 . The principal factor determining the amount of fixed ion released by these extracting solutions was the fixable ion/replacing ion ratio in the solution. The effectiveness of a given ratio depended upon: 1) the amount of extracting solution in relation to the amount of clay mineral, 2) the type of clay mineral, 3) the per cent saturation of the fixing capacity of mineral, 4) the pH of the system, 5) the fixable cation present, and 6) whether the fixable ion was present on the mineral or added in the extracting solution.

These findings make necessary a complete re-examination of methods used in extracting fixed ions. Alkaline distillation was the most efficient method of extracting fixed NH_4 because the released NH_4 did not accumulate in solution to block further release. The blocking effect of traces of K could be overcome in alkaline distillation by distilling for a prolonged period. The ineffectiveness of salt extractions was due to the accumulation of NH_4 in solution. The replacing power of salt solutions was increased as the pH was decreased.

Fixable ions are preferentially adsorbed by minerals that fix these ions. In a mixture of NH_4 and Na salt, vermiculite was completely saturated with NH_4 when there were 2 NH_4 ions/100 Na ions in the solution. Vermiculite adsorbed more NH_4 than K from a solution containing both ions.

The results of this study help explain many results reported in the literature. For example, the fact that soils seem to have a characteristic level of exchangeable K can be explained by the K/other cation ratio on the exchange complex. The results in the literature concerning the low availability of fixed NH_4 can be explained on the basis of the blocking effect of small amounts of K and need to be re-evaluated in light of these findings.

¹Doctoral theses no. 1621, submitted December 10, 1954. Chairman of Committee, George Stanford, Department of Agronomy.

²B.Sc., University of Nebraska, Lincoln, Neb., 1942. M.Sc., Ibid., 1948. Assistant Professor.

Sodium tetraphenyl borate was used in this investigation to precipitate K in the extracting solutions. With this reagent it was possible to study the effect of the K/replacing ion ratio on the extraction of fixed ions. By maintaining this ratio at a low level considerable quantities of K were extracted from illite. This K precipitating reagent apparently has not been previously used in soils studies, but holds great promise for future studies of K in soils.

Further studies are needed to determine the NH_4 fixing capacity of soils and to determine how this fixation influences the utilization of NH_4 fertilizers.

INTERRELATIONSHIPS OF MICROORGANISMS IN CREAM¹

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It was desired to secure information concerning the specific lipolytic, proteolytic, and other deterioration values resulting from the growth of common contaminating organisms in cream. Excellent quality 35 per cent cream was sterilized and the native enzymes inactivated, by intermittent steaming for 1 hour on each of 3 successive days. Groups of samples were inoculated with an organism commonly encountered in dairy products and incubated at 10, 20, and 30°C for a maximum of 10 days or until the cream deteriorated below the level of commercial acceptability. The individual organisms also were combined with Streptococcus lactis and both cultures inoculated into similarly sterilized cream in order that the growth and fermentation pattern of the two combined organisms could be observed. The organisms were Geotrichum candidum, Torula cremoris, Pseudomonas fragi, Aerobacter aerogenes, Lactobacillus casei, Bacillus subtilis, and Streptococcus lactis. The above group includes a causative organism for each of the most common microbiological defects occurring in dairy products. The cream samples were analyzed at 0, 1, 3, 5, 7, and 10 days for organism population, titratable acidity, pH, water-insoluble acid (W.I.A.), free tryptophan and commercial organoleptic grade. Samples of excellent, medium, and poor quality commercial, raw, uninoculated cream were incubated and analyzed in the same manner.

G. candidum and P. fragi were extremely lipolytic and produced high W.I.A. values in cream. G. candidum produced maximum lipolysis and population at 30°C with 8,344 mg of W.I.A./100 g fat formed in 10 days. P. fragi produced maximum population at 20°C and maximum lipolysis at 30°C, with a W.I.A. value of 6,855 mg/100 g fat occurring in 10 days, indicating that the optimum temperature for the lipase of P. fragi was above the optimum temperature for organism reproduction. Within the range studies, organoleptic deterioration was greater at 30°C with both lipolytic organisms. In cream containing only G. candidum, rancid flavors were apparent at W.I.A. values of 840 and 1,027 mg/100 g fat but when S. lactis was combined with G. candidum, rancid flavors were evident at W.I.A. values of 329 and 402 mg/100 g fat. G. candidum produced rancid flavors at lower W.I.A. values than P. fragi.

Decreases in W.I.A. in the presence of S. lactis were encountered in several instances. Utilization of W.I.A. by S. lactis was demonstrated by adding known quantities of oleic acid to S. lactis cultures in sterile cream and quantitatively measuring the amount of decrease.

Considerable proteolysis, as measured by liberation of tryptophan, occurred in sterile cream inoculated with B. subtilis, P. fragi, and L. casei. B. subtilis was the most proteolytic and produced 46 ppm of free tryptophan on the third day at 30°C. Bitter flavors suggestive of proteolysis uniformly occurred when the free tryptophan values reached 18 to 25 ppm. During the incubation period fluctuations in free tryptophan, greater than the limit of experimental error, frequently occurred. The fluctuations were attributed to a lack of coordination between organism utilization and enzyme liberation of free tryptophan.

The presence of S. lactis inhibited the population development of T. cremoris,

¹Doctoral thesis no. 1570, submitted July 2, 1954. Chairman of Committee, F. E. Nelson, Department of Dairy Industry.

²B.S., Kansas State College, Manhattan, Kans., 1936. M.S., Texas Technological College, Lubbock, Texas, 1940. Graduate Assistant.

P. fragi, *B. subtilis*, and *A. aerogenes*. The beginning of population declines generally was associated with maximum *S. lactis* population and minimum pH. The presence of *S. lactis* stimulated the population development of *G. candidum*. The normal population development of *S. lactis* was inhibited by the presence of *A. aerogenes* and *L. casei*. *T. cremoris* and *A. aerogenes* caused the most rapid organoleptic deterioration in cream, but neither organism produced significant quantities of W.I.A. or free tryptophan.

The presence of *S. lactis* and the accompanying low pH due to lactic acid accumulation inhibited W.I.A. production by the lipase of the lipolytic organisms. Samples of cream containing high mold and lipolytic bacteria populations usually showed low W.I.A. values in the presence of low pH. Low pH also reduced the activity of proteases elaborated by the proteolytic organisms. Proteolysis usually ceased when the pH declined to 4.50-4.65; however, the proteases elaborated from the combination of *S. lactis* and *L. casei* continued to be active below pH 4.0. Instances were observed in which lipase and protease activity continued after organism population began to decline, indicating that the enzymes functioned independent of cell growth.

Seven samples of grade AA or A cream contained from 0.4 to 2.5 ppm of free tryptophan and from 128 to 444 mg of W.I.A./100 g fat. Fourteen samples of grade B cream contained from 1.6 to 11.9 ppm of free tryptophan and from 59 to 819 mg of W.I.A./100 g fat. Ten samples of grade C cream contained from 1.0 to 21.6 ppm of free tryptophan and from 61 to 639 mg of W.I.A./100 g fat. Fourteen samples of commercial butter, randomly selected, ranged from AA to Cooking Grade in flavor and contained from 0.9 to 17.0 ppm of free tryptophan.

Considerable fluctuations which occur in quantities of W.I.A. and free tryptophan during holding of cream limit the ability of these chemical tests to accurately assess quality. Organism activity could cause cream to change from an illegal to a legal category during progressive deterioration. Chemical tests should be used as a supplement to, and not in lieu of, organoleptic grading.

CANADIAN FREIGHT RATE CONTROL BY STATUTE¹

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The freight rates which Canadian railways charge for the transportation of cereal grain in western Canada are very low relative to the rates charged on other commodities. These low rates were set by Parliament as a result of the Crow's Nest Pass Agreement which was made in 1898 between the Canadian Pacific Railway and the Dominion Government. Canadian Pacific, in return for a cash subsidy and a large tract of land, agreed to carry grain at a low fixed rate in perpetuity. The freight rates on most other commodities are set by the Board of Transport Commissioners which is an independent tribunal exercising powers granted to it by the Railway Act. The term "statutory rates" is applied to the freight rates on cereal grain to distinguish them from freight rates established in the usual manner by the Board. These different methods of setting freight rates have economic consequences to the whole of Canada, but before discussing those consequences, the problem of the extent to which there is an inherent contradiction in this "mixed" type of control must be analyzed.

The theoretical aspects of delegated authority confirm the necessity for a reconciliation between the theory of democratic rule and the administrative requirements of a positive state. In Canada, while the requirements of national policy have resulted in much positive direction of economic activity by the state, the concept of cabinet responsibility has provided the means by which control over executive action is maintained by Parliament. The jurisprudence of the Board of Transport Commissioners and their *modus operandi* have taken cognizance of this fact and potential areas of conflict, most particularly in regard to the establishment of "just and reasonable" rates,

¹Doctoral thesis no. 1613, submitted December 6, 1954. Chairman of Committee, Geoffrey Shepherd, Department of Economics and Sociology.

²B.Sc., University of Alberta, Edmonton, Canada, 1945. M.S., Iowa State College, Ames, Iowa, 1946. M.A., University of Toronto, Toronto, Canada, 1949. Research Fellow, Agricultural Experiment Station.

have been avoided by the Board's use of less stringent types of permissive action for the carriers. A system of rate control has evolved which accommodates the restrictions upon Board action imposed by "statutory rates" and which removes what at first appear to be irreconcilable elements.

There have been a number of economic consequences of the Agreement. From the historical standpoint the existence of statutory rates which arose as a result of the Crow's Nest Pass Agreement did not materially affect the volume of settlement in western Canada. The west would have been settled without these special rates at about the same rate as it was settled with the rates. In an absolute sense, the effect of the Agreement on resource utilization has been too small to measure, but in a relative sense the Agreement has tended to encourage cash crop production in western Canada. It has had the effect of shifting resources from the livestock enterprise to grain enterprise and it has increased the attractiveness of feed lot finishing in central Canada.

The Agreement has also shifted the burden of post war freight rate increases from the grain grower to other types of farm organization, to consumers, and to other industry. The cumulative change in the level of Canadian nongrain freight rates since 1948 has been an increase of 98.2 per cent. If grain rates had been increased the necessary change would have been only 82.2 per cent. Post war increases in the nongrain tolls have been higher because of the Agreement and consequently local industry which is advantaged by high freight costs has benefited. Export industry, other than grain, has been placed in a less favorable position. From a purely regional standpoint the total freight bill in western Canada has been reduced and the freight rate savings which have resulted from the Agreement have probably been retained by the grain growers.

The effect of the Agreement on the railways of Canada cannot be analyzed with certainty. To the extent that total railway earnings have been adjudged satisfactory by the Board of Transport Commissioners the railways have not been affected by the Agreement unless they have a preference for the manner in which their revenues are earned. In those periods when railway earnings have fallen below the permissible levels established by the Board, the Crow's Nest Pass Agreement may have prolonged this deficiency condition.

Certain general conclusions regarding the control of railway freight rates by statute emerge from a consideration of the foregoing facts. It is apparent that statutory freight rates introduce a further rigidity into the freight rate structure. The degree to which they contribute to rigidity will depend upon the type of statutory control that is used. In the case of the Crow's Nest Pass Agreement, which prescribes the absolute rates, the rates are constant until Parliament dictates a change. There is no "built in" flexibility in the Crow's Nest Pass Agreement such as may be found in other agreements which provide for automatic adjustments as price levels, and other factors, change.

Statutory control appears to result in freight rates which are relatively low for the particular commodities affected. To the extent that statutory control makes freight rates low and rigid there is a tendency for this type of control to misdirect resources. The direct effect of the Agreement is to misdirect agricultural resources but indirectly industrial and transportation resources might also be affected.

There are several alternate means of controlling the freight rates on grain. To what degree would the adoption of one or other of these methods overcome the difficulties that have been noted? The most obvious suggestion is that rates now controlled by statute be placed under the jurisdiction of the Board of Transport Commissioners. In this situation grain rates would be dealt with in the same fashion as most other rates. To make such a change successful it would require that the Board establish commodity rate scales for grain which reflected circumstances and conditions in the grain industry. The Board does not now consider economic circumstances in an industry when it establishes rates for that industry. To direct the Board to do so in the case of grain rates might have repercussions of a very severe kind throughout the whole railway rate structure. Instead of requiring that the Board fix the rates on grain, a special committee established by Parliament could be given the task of fixing a just and reasonable scale of rates for grain. Such a committee, composed of appointees experienced in various phases of the transportation and marketing of grain and specifically including representatives of the railways and the grain producers, and appointed for a term of years, would be responsible for recommending to the Government a scale of rates to be applicable on grain for each crop year. The committee would have available to it the technical assistance of the Canadian Wheat Board, the Board of Grain Commissioners and the Board of Transport Commissioners.

The basic task of the Committee would be to arrive at a scale of rates for grain which would be just and reasonable both to the shippers and to the carriers. The following matters would be of particular concern:

1. The probable demand for, and the supply of, western produced grain for the year under consideration.
2. The competitive situation for western produced grain in its usual markets and particularly the probable price for such grain.
3. The out-of-pocket cost and the fully distributed cost of transporting western produced grain to export positions. Associated with these costs would be such matters as the volume of other traffic, the general rate level, and the financial condition of the carriers.
4. The level of rates on other agricultural products, particularly on those products which are more or less competitive with grain in the area.

It is conceivable that under certain circumstances the scale of rates recommended by the Committee might be considered too high or too low by the Government. In such a case the effective rate to the grain producer could be altered by the direct payment to the railways of a subsidy or in the alternative by the collection of a bounty. To the extent that existing freight rates are capitalized into land values, the payment of a subsidy might be considered necessary in the initial stages of this application.

ALFALFA SEED PRODUCTION IN CENTRAL IOWA AS INFLUENCED BY HONEY BEES AND CERTAIN OTHER FACTORS¹

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The relationship of honey bees, other pollinators, injurious insects, weather factors, and agronomic factors to alfalfa seed production was studied in and near Ames in 1950 and 1951. In 1950, four fields were selected for study. Four colonies of honey bees per acre were moved into two of these fields, but bees were not moved into the other two. In 1951, a 28-acre field designed for studying alfalfa seed production and the influence of red clover as a competing crop for pollinators of alfalfa was used. Nectar secretion and the behavior of honey bees collecting nectar and pollen as related to seed production were also investigated. In 1950, all fields were sprayed with insecticides to eliminate the influence of injurious insects on seed production, but in 1951 several insecticidal treatments were compared in the seed production study.

Attempts to establish two levels of bee populations in order to investigate the value of honey bees as pollinators of alfalfa were not successful in 1950. Many bees which were moved into the experimental fields both in 1950 and 1951 foraged in neighboring fields, and bees from apiaries not in the experiment increased bee populations in fields where low populations were desired. However, some consistent differences in bee populations were found both in 1950 and in 1951 so that correlations between bee populations and seed yields and correlations between each of these factors and other variables could be calculated.

Seed yields were more closely correlated with honey bee populations than with any other factor studied. The regression of seed yields on honey bee populations showed that an increase of 62.2 pounds of seed per acre might have been expected for each increase of one bee per square yard under the conditions of the 1950 experiment and 29.9 pounds per acre under the 1951 conditions. Few wild bees were observed in square-yard plots used for estimating bee populations, but wild bees were observed

¹Doctoral thesis no. 1634, submitted February 22, 1955. Chairman of Committee, J.H. Lilly, Department of Zoology and Entomology.

²B.S., Utah State Agricultural College, Logan, Utah, 1948. M.S., Ibid., 1949. Graduate Assistant, Agricultural Experiment Station.

and they undoubtedly aided pollination. A few cantharids were counted in 1951, but their influence on seed yields was considered negligible.

More honey bees were counted in alfalfa than in red clover, but they much preferred red clover as a source of pollen. Seventy per cent of the bees observed in alfalfa carried nectar, but none was observed collecting pollen. On red clover more than 88 per cent of the bees examined carried pollen.

Honey bees were more plentiful on second crop alfalfa than they were on first crop, but they tripped more flowers on first crop, and seed yields on first crop were greater than those from second. The rate honey bees visited alfalfa flowers was most rapid where bees were most abundant, but there was no direct relationship found between seed yield and the rate of visitation.

Honey bees tripped an average of 0.25 per cent of the second crop flowers visited in 1950 and 0.27 in 1951. Competition for the bees by other plants appeared to influence the low efficiency of honey bees in pollinating alfalfa.

Seed yields were consistently better where injurious insects were controlled than on unsprayed areas, and sprayed plots consistently had more bees on them than check plots on second crop alfalfa.

The influence of weather factors on the value of honey bees as pollinators appeared negligible on the basis of analyses of seasonal averages, but analyses based on 2-day observation periods showed that differences in bee populations and rate of visitation were associated with short-term variations in weather. Light intensity and air temperature appeared to be positively correlated with rate of bee visits to alfalfa flowers on a basis of seasonal averages.

Differences in plant stand were too small to show correlations with honey bee populations or seed yields. Elevation (field topography) showed a positive correlation with bee populations and seed yields. The tallest plants produced the most seed, and there was a trend toward taller plants where the amounts of available phosphorus and potassium in the soil were greatest. Soil pH was one of the factors most closely correlated with bee populations and seed yields, but this association was negative and presumably indirect. Very little correlation was found between soil pH and either available phosphorus or available potassium as measured in these studies. Phosphorus and potassium at the levels found in the soils tests showed little relationship between these minerals and seed yields, but both minerals show a trend toward positive correlation with bee populations. Available phosphorus was positively correlated with available potassium, and available potassium was positively correlated with plant height. There was little correlation between the levels of phosphorus and potassium found in alfalfa plants and those levels found in soil where the plants grew. Larger amounts of phosphorus and potassium were found in first crop alfalfa plants than in second crop, and plants sprayed with insecticides had a higher average potassium content than the non-sprayed areas. Soil where first crop plants were grown showed greater amounts of available phosphorus and potassium than soil where the second crop plants were grown.

Honey bee activities and seed yields were not found to be correlated with the quantity or quality of sugar in nectar. There was little relationship between the rate bees could be captured and the bee populations as indicated by counts made on square-yard plots.

Multiple correlation studies indicated that approximately 41 per cent of the variability in honey bee populations was associated with plant height, elevation, and light intensity; that 16 per cent of the variation in the rate bees visited alfalfa flowers was linked to light intensity and air temperature; and that 61 per cent of the variability in seed yields appeared to be lineally associated with elevation, soil pH, and honey bee populations.

FARMERS' INVESTMENT DECISIONS IN RELATION TO TIME AND UNCERTAINTY¹ROLAND J. HILDRETH²

Department of Economics and Sociology

The problem for this thesis was an attempt to describe and predict or explain certain aspects of capital investment decisions by farmers. Opinions on selected aspects of decision-making were obtained. Hypotheses were obtained from a model or theoretical solution of the problem. According to the model, the optimal investment decision is influenced by: 1) initial conditions such as amount and present condition of current assets, 2) expectations of prices and yields, 3) the preference pattern for various items including time and uncertainty, and 4) the production function.

Data were collected from a sample of owner-operators in central Iowa. Personal interviews were used. The data were analyzed by means of regression, contingency tables, comparisons of averages, and chi-square analysis.

Results indicated that not all investment decisions are of a genuine nature in that certain decisions were made without the formulation of expectations. Evidence was presented that different decisions are made by different methods. It was found that only a few farmers were innovators in that they were willing to act on their appraisal of new processes or new equipment. Wives were the most frequently used source in making investment decisions.

Measures of variables used to predict and explain planned capital investment were developed. Total capital, equity, and a measure of risk discount were the major factors in the explanation of total planned capital investment. A multiple regression equation was fitted as a logarithmic function. The equation obtained was

$$\hat{y} = 0.0936X_1 + 1.1338X_2 + 0.7963X_3 - 0.2349$$

where X_1 = total capital

X_2 = equity

X_3 = risk discount

and y = total planned capital investment.

An R^2 of 0.35113 was obtained. This indicates that the above factors explain little more than 35 per cent of the variation. Other factors tested were level of 1960 expectations of the index of prices received by Iowa farmers, range of 1960 expectations, and a measure of time discount. These factors had little relationship to total planned capital investment.

Relationships of various predictive factors to the individual investment items were investigated. Capital, liquid assets, and preference for type of work were highly associated with planned land investments. Factors closely related to tile and land improvements were capital, liquid assets, and acres operated. The same factors were also closely related to planned fertilizer capital investments. Other related factors were range of 1960 expectations and acres operated. Only level of 1960 expectations and acres operated appeared to have any relationship to planned livestock investment. Highly related factors for planned building investment were capital, age, and liquid assets. Time and risk discount were also related to planned building investment. The factors highly related to planned machinery investment were capital, age preferences for type of work, acres operated, and liquid assets. Other slightly related factors were equity and time discount.

Relationships between past investment and some aspects of initial conditions, capital, and age were found. Also some relationship between past investment and preference for type of work was discovered.

No one clear-cut method of decision-making in the case of land purchase was found. Many diverse factors are considered in the purchase of land.

Three concepts of economic horizon were obtained. These concepts, 1) time length of production plan, 2) year \$1,000 worth nothing, and 3) planned length of time in farming, were not closely related.

¹Doctoral thesis no. 1624, submitted December 13, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

²B.S., Iowa State College, Ames, Iowa, 1949. M.S., Ibid., 1950. Instructor.

Evidence was obtained indicating the farmers were relatively unresponsive to changes in interest rate. They appeared to be more responsive to an upward movement of rates than a downward movement. Some evidence was obtained that the interest rate may have more influence on land loans than on production loans.

Evidence supporting the principle of increasing risk was obtained.

The farmers appeared to have internal capital rationing rather than external capital rationing. The main reason for the internal rationing appeared to be uncertainty.

Opinions about uncertainty of farming compared to other activities were obtained. Also a list of "risky" and "safe" enterprises and practices was obtained from the farmers.

The mean equity ratio which the farmers considered safe was 0.60. A high equity ratio was considered safer than a high level of liquid assets.

The measure of time discount was found to be closely related to the choice of hypothetical income plans. The choices of the income plans also provided some evidence that income stability may not be the universal goal of farmers.

A majority of the farmers preferred two short-life barns to one long-life barn for various reasons; mainly, flexibility. Other opinions about use of extra capital and pay-off periods for certain assets were obtained.

Finally, limitations of the study were discussed and suggestions for future research were made.

INTRODUCTION AND SPREAD OF NECROTIC RING SPOT VIRUS IN SOUR CHERRY NURSERY TREES¹

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Department of Botany and Plant Pathology

Nurseries in southwest Iowa produce a large portion of the trees for planting and maintenance of sour cherry orchards in the Great Lakes region. During recent years much importance has been placed on the virus disease known as sour cherry yellows as the cause of much loss of yield in those orchards. Consequently, there has been an increasing demand by the orchardists for cherry nursery stock free of yellows.

Proof that virus is seed-transmitted in Prunus mahaleb L. made it desirable that the status of both the seed-producing orchards and the seedlings emanating therefrom be further clarified. Furthermore, possibilities of indexing P. mahaleb seedling rootstocks and knowledge of possible virus latency in that species would be important in producing virus-free cherry trees. That virus contamination found in plum nursery trees might possibly be due to diseased P. americana rootstocks pointed up the problem of seed transmission in the case of P. americana as well as the contamination status of plum scion orchards.

Although there was some proof that spread occurs in sour cherry nursery blocks, it was felt that further proof of spread along with knowledge of pattern of spread, and thereby possible indication of means of spread, would be helpful. Further proof of suitability of P. tomentosa as an indexing host was also needed.

Suitability of P. tomentosa as an index plant was proven when P. tomentosa seedling trees were inoculated with seven sources of necrotic ring spot and held at 60, 70, or 80°F. P. tomentosa reacted to all sources at all three temperatures. Incubation period was progressively shorter with increase in temperature. Relative length of incubation period for a particular source was comparable at all three temperatures. Sources could not be identified by type of symptoms produced on P. tomentosa.

Further demonstration of the suitability of P. tomentosa as an indexing host was by inoculation of P. tomentosa with buds from P. mahaleb seedling trees previously inoculated with 14 virus sources. P. tomentosa succeeded in demonstrating presence of necrotic ring spot virus in 96.8 per cent of infected P. mahaleb trees. There was indication of slight incompatibility between P. mahaleb buds and P. tomentosa stocks.

¹Doctoral thesis no. 1586, submitted July 17, 1954. Chairman of Committee, W.F. Buchholtz, Department of Botany and Plant Pathology.

²B.S., Iowa State College, Ames, Iowa, 1950. M.S., Ibid., 1951. Graduate Assistant, Agricultural Experiment Station.

Lack of latency of necrotic ring spot virus in P. mahaleb was shown by reinoculating seedling trees originally inoculated with 14 sources of necrotic ring spot. All but three previously inoculated trees showed symptoms when reinoculated the second year. Furthermore, among trees originally inoculated, but not reinoculated the second year, all but one exhibited necrotic ring spot symptoms. Among these latter were three which exhibited severe symptoms. After the original inoculations, P. mahaleb seedling trees held at 60°F reacted to all 14 sources of necrotic ring spot virus, to only four at 70°F and to none at 80°F. Symptoms even at 60°F were variable.

Continued virus contamination of P. mahaleb seed orchards was indicated by indexing a California orchard in 1950 and 1951. Percentage of infected trees in the orchard in 1950 was 9.4. Indexing in 1951 after removal of trees found to be diseased in 1950 showed 31.6 per cent diseased trees. The apparent increase in number of diseased trees suggests, among other things, the possibility of nonsystemic infection of P. mahaleb. Indexing in 1950 of a seed orchard in Washington revealed 17.4 per cent of necrotic ring spot infected trees.

Contamination of P. mahaleb seedling rootstocks and of trees propagated on P. mahaleb rootstocks infected with necrotic ring spot was shown when six of a sample of 50 P. mahaleb seedlings were found to be infected in 1952. Furthermore, 1954 indexings indicated necrotic ring spot infection in 12 of 29 Gilbert Montmorency cherry trees and six of 15 Kansas Sweet Cherry trees propagated in 1952 from virus-free scionwood but on unindexed P. mahaleb rootstocks.

That plum scion trees may play a part in contamination of plum varieties in the nursery was revealed when six of 15 varieties growing in a nursery scion orchard were definitely proven to contain necrotic ring spot virus when indexed on Montmorency cherry and P. tomentosa in the greenhouse. There was inconclusive evidence of some infected trees of all 15 varieties when the trees were field indexed on P. tomentosa and P. persica, variety Elberta, seedlings.

Definite proof was offered of transmission of necrotic ring spot virus through seeds of P. americana. Of 43 plum thickets, 19 were found to be infected. Indexings of seedlings emanating from seven diseased and six "healthy" thickets revealed that in every case diseased plum thickets yielded some diseased seedlings. Conversely, the six "healthy" thickets yielded none but healthy seedlings. A considerable number of seedlings in a sample grown from commercial seed were infected. Actual percentages of seed transmission were not determined. Drastic symptoms amounting to death of the P. tomentosa indicator plant occurred in several cases when buds from diseased plum seedlings were inserted.

Further proof is submitted of spread of necrotic ring spot in sour cherry nursery blocks in southwest Iowa. Indexing twice during the growing season in 1951 of identical samples of 100 trees, two from unisolated fields and one from a field isolated from other Prunus species by one-fourth mile, revealed initial percentages of infected trees to be 47, 68, and 9, respectively, and final percentages of 58, 77, and 13, respectively, with consequent increases of 11, 9, and 4, in that order, during a 30-day period.

In an experiment designed to reveal pattern as well as rate of spread in 1952, ten groups of 11 adjacent trees each in three unisolated fields were indexed twice during the growing season. The center tree of each group had been inoculated with necrotic ring spot virus. Initial percentages of infected trees (omitted inoculated trees) were 17, 10, and 12 while final percentages were 22, 16, and 18, respectively, with consequent increases of 5, 6, and 6, in that order, over a period of 47 days. Six of the 17 new cases were adjacent to older cases, eight appeared in groups of new cases, and three were entirely isolated.

Transmission of necrotic ring spot through artificial root grafts was proven by making intra- and inter-species root grafts between pairs of seedling trees of P. americana, P. mahaleb, and P. avium, variety Mazzard, and intra-varietal root grafts between pairs of P. cerasus, variety Montmorency, budded on P. mahaleb understocks and P. persica, varieties Polly, Halehaven, and Elberta, all budded on Elberta seedling understocks. One member of each pair was inoculated with a source of necrotic ring spot virus. Root graft transmission was successful except where the root graft or inoculation bud graft was a failure. Field observations revealed no naturally occurring root grafts in two-year-old sour cherry nursery blocks. It is evident that necrotic ring spot will pass through artificial root grafts. However, since no root grafts occur in the field, and there is some spread to other than adjacent trees, other means such as above-ground insects must account for spread of necrotic ring spot in sour cherry nursery blocks.

CYTOLOGY, MORPHOLOGY, AND AMINO ACID CHARACTERIZATION
OF A PUTATIVE AGROELYMUS AND ITS PRESUMED PARENTS¹HARLOW J. HODGSON²

Department of Agronomy and of Botany and Plant Pathology

A number of grass plants of suspected hybrid origin were found in the vicinity of Palmer, Alaska, in the summer of 1949. High sterility, extremely irregular meiotic behavior, intermediate morphology, vigor, and chemical composition with respect to free amino acids indicated hybridity. These plants could have resulted from hybridization of Elymus canadensis L. and either Agropyron sericeum Hitch. or A. repens Beauv. and therefore were referred to as XAgroelymus.

Although conditions existed which favored backcrossing to all three putative parents no backcross seed was found. F₂ progeny likewise were not obtained. Attempts to synthesize the hybrid failed.

Cytological studies were made on microsporogenesis in A. sericeum, E. canadensis, and XAgroelymus. All had a somatic chromosome number of 28.

Meiosis in A. sericeum was predominantly regular although some irregularity existed in the form of univalents and bridges. No multivalent associations were noted. Pollen sterility approximated 10 per cent and was almost equal to the per cent of anaphase I figures containing bridges. It was assumed that laggards found in 20 per cent of the anaphase I figures usually reached the poles in time to be included in the daughter nuclei.

Meiosis in the largely self-pollinated E. canadensis was quite regular. The only irregularities found were bridges in approximately 10 per cent of the anaphase I figures. Fourteen bivalents were observed in all determinable diplotene, diakinesis, or metaphase I figures. No univalents or multivalents were observed. Pollen sterility approximated 25 per cent and exceeded the amount expected on the basis of meiotic irregularity.

Meiosis in XAgroelymus was highly irregular although apparently normal sporocytes were observed at all divisional stages. Chromosome pairing at metaphase I ranged from largely bivalent associations to largely univalents. Multivalents were frequent though usually not more prevalent than one or two per cell. Some multivalents appeared to involve more than four chromosomes. The complete pollen sterility of this hybrid could not be explained entirely on the basis of meiotic irregularity. Cryptic structural hybridity was suggested as the explanation.

Amphidiploid seed was produced from colchicine treated sectors of XAgroelymus. Twenty seeds were produced in 1953 and over 40 grams were collected in 1954. Nineteen progeny from treated plants were grown in 1954 and the per cent of florets which produced seed ranged from 0-20 per cent. Continued selection in subsequent generations should result in increased fertility.

Morphological studies were made from herbarium specimens in mass collections. Measurements were made on those characters which could be treated quantitatively and descriptive data were obtained on these and other characters. XAgroelymus more nearly resembled A. sericeum than A. repens. With regard to several characters it appeared impossible that A. repens could have been the Agropyron parent.

Chromatographic techniques were used in characterizing free amino acid content of the four grasses. Five tissues were analyzed for presence or absence of 13 amino acids. Seven instances were found where the four grasses differed and in each case A. repens was deficient in an amino acid which was present in the other three grasses.

It was concluded that XAgroelymus was an intergeneric hybrid between Elymus canadensis and Agropyron sericeum and corresponds to XAgroelymus palmerensis described elsewhere.

This hybrid exhibited considerable heterosis by producing considerably more growth and a greater number of flowering culms than either parent. It began growth very early in the spring and reached grazing height earlier than any other grass. These characteristics were of particular interest from the standpoint of potential economic value.

¹Doctoral thesis no. 1642, submitted March 11, 1955. Chairmen of Committee, J.E. Sass, Department of Botany and Plant Pathology, and I.J. Johnson, Department of Agronomy.

²B.S., University of Wisconsin, Madison, Wisc., 1939. M.S., Iowa State College, Ames, Iowa, 1948.

LIFE TESTING IN CONTROLLED ENVIRONMENTAL CONDITIONS¹JOHN F. HOFMANN²

Department of Statistics

The basic problem considered is the evaluation of a physical system operating under environmental stresses with respect to the time of trouble-free operation. Specifically, it is necessary to estimate the probability of failure prior to a given time. This is done by utilizing a distribution of time to failure which appears reasonable, and which is specified by the mean time to failure. The problem, therefore, reduces to one of estimating mean times to failure under various environmental conditions. A method of employing laboratory experiments to estimate the effect of environmental stresses on mean time to failure is studied.

Based on the assumptions

- a) that time to failure follows an exponential distribution, and
- b) that the logarithm of mean time to failure can be expressed as a linear function of the logarithms of the environmental stresses,

two alternative methods of estimating the parameters of the linear model and interpolated mean times to failure are derived. The first of these methods gives least squares estimates of the parameters as linear functions of the logarithms of the geometric means of the times to failure of units operated in the same combination of stresses. The same linear combinations of the logarithms of the arithmetic means provide an alternative method of estimation which is shown to be more efficient than least squares, both for estimating the parameters of the linear model and for interpolating in the model to predict mean failure time.

When the least squares method of estimation is employed, the accompanying analysis of variance provides statistics to test the hypotheses

- a) that the errors in the linear model are distributed as the logarithms of exponentially distributed variates, and
- b) given that hypothesis a is accepted, that the linear model is adequate to describe the variation of mean failure times with environmental stresses.

The above results are obtained for an experiment involving arbitrary combinations of environmental stresses, with arbitrary sample sizes at each combination. The specific results obtained, when the experiment takes the form of a 2^P factorial experiment are also given. In this latter case approximate distributions for the estimates of the parameters of the linear model are derived. The results obtained in the discussion of 2^P factorial experiments are directly applicable when a 2^{-r} -th fractional replicate is employed.

¹Doctoral thesis no. 1681, submitted June 7, 1955. Chairman of Committee, Oscar Kempthorne, Department of Statistics.

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PART I. COMPARISON OF 1,2- AND 1,3-ELIMINATION REACTIONS
PART II. FACTORS WHICH INFLUENCE THE IONIZATION OF
CARBOXYLIC ACIDS¹

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PART I

1,3-Elimination reactions have been compared directly with 1,2-eliminations by the reaction of α -bromobutyronitrile and α -chlorobutyronitrile with a series of bases in various solvents. One weakly basic nucleophile, piperidine, was employed but the major part of the investigation utilized the potassium alkoxides or *n*-butanol, *sec*-butanol, and *t*-butanol. The elimination reactions were run in benzene, benzonitrile, and the previously mentioned alcohols. The product distribution was determined by an infrared analysis.

Piperidine gave only a substitution product, while elimination was observed with the strong bases. 1,3-Elimination was favored by a combination of high basic strength of the attacking species and a low dielectric constant of the medium. The rate of the reaction was observed to be faster when α -bromobutyronitrile was used as the substrate, than when α -chlorobutyronitrile was used. The chloronitrile, however, gave a larger proportion of cyclopropyl cyanide than the bromonitrile. A somewhat faster rate was also observed with both substrates in the low dielectric media than in the higher dielectric solvents.

The increased rate that was qualitatively observed with α -bromobutyronitrile together with the observed product distributions have been interpreted as evidence that bromine promotes 1,2-elimination to a greater extent than it does 1,3-elimination. 1,3-Elimination is thus less sensitive to the leaving group than olefin formation. The charge distribution in the transition state of 1,3-eliminations must be more dispersed than that of 1,2-eliminations, since cyclization is favored in low dielectric solvents.

The above facts are consistent with two possible mechanisms which both fit second order kinetics and cannot be distinguished on the basis of the present data. One is a two-step process initiated by a rapid formation of nitrile anion by reaction with the base, followed by a rate-determining displacement of halogen. The second mechanism involves a concerted process with the hydrogen and halide ions being removed simultaneously as is known in the case of 1,2-elimination reactions.

PART II

The apparent dissociation constants of some highly hindered aliphatic carboxylic acids were measured at 40° by a potentiometric titration in "50 volume per cent" methanol-water solution. The apparent pK_A values and the dissociation constant are listed in Table 1.

The acidweakening effect observed in this investigation is consistent with the postulation that two effects are sufficient to explain the acidity of sterically hindered organic acids. Since steric inhibition of resonance cannot be a factor in these aliphatic acids, the results may be explained by steric hindrance to solvation of the carboxylate anion by the bulky groups in the α position.

A limited correlation was obtained between Hammett ρ constants and effective dielectric constants. The effective dielectric constants were calculated by means of a previously modified Westheimer-Kirkwood treatment which utilized an oblate spheroidal model. The correlation was valid for pure solvents with dielectric constants as low as 17, and for dioxane-water mixtures with dielectric constants as low as 15. The pure solvents and the mixtures did not fall on the same line, however. This was interpreted as a result of the preferential solvation of hydrogen ions by water molecules in the mixture.

¹Doctoral thesis no. 1593, submitted August 16, 1954. Chairman of Committee, George S. Hammond, Department of Chemistry

²B.S., St. Lawrence University, Canton, New York, 1949. M.S., *Ibid.*, 1950. Research Fellow, Chemistry and Industrial Science Research Institute.

Table I

Ionization constants of hindered acids in 50
"volume percent" methanol-water at 40°

Acid	Apparent pK_A			$K \times 10^7$
	1/4	1/2	3/4	
acetic	5.57	5.55	5.55	27.6
methylneopentylacetic	6.04	6.05	6.07	8.90
methyl- <u>t</u> -butylacetic	6.25	6.25	6.24	5.63
ethyl- <u>t</u> -butylacetic	6.31	6.32	6.31	4.90
diisopropylacetic	6.40	6.40	6.39	3.98
triethylacetic	6.44	6.44	6.44	3.62
dimethylneopentylacetic	6.49	6.51	6.51	3.13
dineopentylacetic	6.51	6.54	6.62	2.75
dimethyl- <u>t</u> -butylacetic	6.74	6.72	6.71	1.91
methyl- <u>t</u> -butylneopentylacetic	6.88	6.97	7.02	1.10

PREPARATION, PROPERTIES, AND ANALYTICAL APPLICATIONS OF SOME SUBSTITUTED ALICYCLIC VIC-DIOXIMES¹

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The application of organic analytical reagents to the determination of metallic ions has progressed rapidly in the last few decades. Many of these organic compounds have proved to be selective in their action and thereby make possible the determination of one or two ions in the presence of several others.

Perhaps one of the most widely used organic reagents for the determination of nickel is 2,3-butanedionedioxime, commonly called dimethylglyoxime. This compound and many others possessing the vic-dioxime functional group have been studied extensively in their analytical applications for the determination of both nickel and palladium and while much is known concerning the nature of the nickel(II)- and palladium(II)-dioxime complexes, the knowledge is far from complete.

The need for better analytical reagents always exists and even though scores of reports on the application of various dioximes to the analysis for nickel and palladium are in the literature, no one dioxime has been shown to possess all of the characteristics of an ideal reagent.

A series of aliphatic substituted 1,2-cyclohexanedionedioximes, commonly called nioximes, have been prepared which reveal some of the relationships between the properties of the dioximes, their metallic complexes and their respective structures. In addition, some members of the series possess chemical and physical properties that make them especially useful for analytical applications.

¹Doctoral thesis no. 1627, submitted December 16, 1954. Chairman of Committee, Charles V. Banks, Department of Chemistry.

²B.S., Northwestern University, Evanston, Illinois, 1951. Research Assistant, Institute of Atomic Research.

The vic-dioximes investigated were the 3-methyl-, 4-methyl-, 3-ethyl-, 3,6-dimethyl-, 4-isopropyl-, 4-tertamyl-, 4-(1,1,3,3, -tetramethylbutyl)-, and 4-carboxy-1,2-cyclohexanedionedioximes. These compounds were prepared by starting with the substituted phenol and carrying out a multi-step synthesis. The phenols were reduced with hydrogen under pressure to the corresponding cyclohexanols which were then oxidized with potassium dichromate to the cyclohexanones. The substituted cyclohexanones were treated with alcoholic selenium dioxide to yield the vic-diones, and oximations of the vic-diones to the vic-dioximes were accomplished with hydroxylammonium chloride. The over-all yield for 1,2-cyclohexanedionedioximes substituted in the 3-position was approximately 10 per cent while those substituted in the 4-position were obtained in 20 per cent yields. The exceptions to this were the 3,6-dimethyl- and the 4-carboxy -1,2-cyclohexanedionedioximes which were obtained in only 1 to 2 per cent yields.

The dioximes were all similar in chemical properties and differed only in those physical properties that are dependent on the size and weight of the molecule. The melting points of the substituted 1,2-cyclohexanedionedioximes were all within a 40°C range and appeared to be due to destruction of the dioxime group. The nickel(II) and palladium(II) complexes of the substituted dioximes were slightly more insoluble in water than the unsubstituted 1,2-cyclohexanedionedioxime due to the opposing factors of the increased molecular weight and the interference with the intermolecular interaction between the planes of the complexes in the crystalline state by the substituted groups. However, in chloroform these factors work together and the solubilities of the complexes of the substituted dioximes are from 100 to 10,000 times more soluble than the corresponding 1,2-cyclohexanedionedioxime complexes.

The absorption spectra of the dioximes in solution were all very much alike and this indicated that substitution of bulky groups near the oxime group has little effect on the dioxime portion of the individual molecules. Further, little difference was noted in the spectra of the nickel complexes of the substituted dioximes and the 1,2-cyclohexanedionedioxime. On the other hand, a large maximum in the spectra of the nickel(II) and palladium(II) complexes as crystals suspended in water was found not only to vary with the steric hindrance presented by the substituted groups to the intermolecular interaction of the planes of the complexes in the crystal, but also to be a function of the crystal size. The observations concerning these maxima indicated that they were exhibited only with micro crystals and that they probably result from selective scattering of light on the long wavelength side of the true absorption maxima. This type of phenomenon has been previously described as the "Christiansen filter effect."

From investigations of the physical and chemical properties of the series of dioximes, it was thought that the 4-methyl-, 4-isopropyl-, and possibly the 4-tertamyl-1,2-cyclohexanedionedioximes could be advantageously applied to analytical uses.

The gravimetric determination of nickel and palladium with 4-methyl- and 4-isopropyl-1,2-cyclohexanedionedioximes proved successful. Samples of these metals from 5 to 50 mg were determined to the nearest 0.1 mg and for quantities of 1 to 4 mg the average error was less than 0.05 mg. Interferences with the gravimetric determination of nickel(II) were limited to copper(II), cobalt(II), ruthenium(III), iron(II), and iron(III) among the metallic ions studied and these had to be present in nearly gram quantities to offer much interference. All of the ions except for the ruthenium(III) could be masked or removed from solution by previously suggested techniques. Palladium(II) was quantitatively precipitated from aqueous solution at as low a pH as 0.7 and therefore only iron(II), iron(III), and ruthenium(III) interfered. Again, iron could be successfully complexed to prevent interference.

The 4-methyl-1,2-cyclohexanedionedioxime proved to be a very good reagent for the gravimetric determination of nickel and palladium as it possesses the following advantages: A quantitative precipitation of nickel and palladium at pH 3 and 0.7, respectively; no empirical factor necessary for the gravimetric determination of nickel or palladium; the reagent is soluble in water to the extent of 3.4 g per liter; it is not prohibitive in preparative costs.

The 4-methyl- and 4-isopropyl-1,2-cyclohexanedionedioximes were successfully applied to the spectrophotometric determination of both nickel and palladium by employing aqueous suspensions of the metal-dioxime complexes. The peaks used for the determinations were the ones found to be dependent on crystal size, but very reproducible results were obtained by the use of gum arabic as a dispersant. The gum arabic appeared to stabilize the suspension and control the crystal size.

By employing this heterogeneous spectrophotometric method, nickel(II) was determined to the nearest 0.3 mg for samples of 1 to 1,000 γ and palladium(II) in the same range was determined to 0.2 γ . Interferences with the nickel(II) determinations consisted of those cations that form colored dioxime complexes at pH 3 which includes many of the transition metals. By complexing the interfering metallic ions with suitable reagents, most of the interferences were removed and in addition, since the spectrophotometric determination of nickel was carried out at 550 millimicrons, and the interferences did not absorb to any great extent at this wavelength, small amounts of interfering materials did not cause a significant error. Palladium(II) was determined at pH 0.7 to 1:0 and read at 470 millimicrons. With the pH at 0.7 only iron(II) and ruthenium(III) interfered and iron was masked with fluoride or phosphate.

One of the outstanding properties of the substituted 1,2-cyclohexanedionedioximes is the high solubility of both the nickel(II) and palladium(II) complexes in organic solvents, especially chloroform. This property makes possible the quantitative extraction of the complexes into chloroform and subsequent spectrophotometric determinations on the solutions. The extraction technique not only prevents interference by large amounts of nonextractable, highly colored species like chromium(III), but results in an increased sensitivity in the spectrophotometric method. The molar absorptivities of the nickel(II) and palladium(II) complexes are increased two or three times over the heterogeneous method and the extraction is so favorable that a small quantity of chloroform can quantitatively extract the complexes from a water phase 10 times its volume. Microgram quantities can easily be determined and as little as 0.1 part of nickel or palladium per 10,000,000 parts of water can be estimated to 5 per cent by this method.

Since the dioxime complexes of nickel are highly colored and very strong, it was thought that a titration employing a spectrophotometric end point might be possible. This proved to be feasible if the titration was carried out in a mixed solvent of 20 per cent chloroform, 20 per cent water, and 60 per cent methanol. In water alone the kinetics of precipitation of the nickel(II)-dioxime complex were slow, but in the solvent mixture employed, the complex was soluble and the poor kinetics were avoided. The titration proved to be very sensitive and from 15 to 900 γ of nickel were determined with less than 1 per cent error. Interferences were more numerous than with the other techniques investigated since some materials were insoluble in the solvent mixture used. These interferences included arsenic(III), antimony(III), bismuth(III), tin(II), and thallium(I) which hydrolyzed and precipitated.

ULTRAVIOLET LIGHT SCATTERING BY TOBACCO MOSAIC VIRUS NUCLEIC ACID¹

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In this work the ribonucleic acid (RNA) separated from tobacco mosaic virus has been studied by means of light scattering techniques.

An instrument has been designed and constructed that is capable of measuring the intensity of light scattered from solutions at angles from the emergent incident beam of 20° to 150°, and over a range of wavelengths through the visible to near ultraviolet. Inclusion of calcite prisms provided means for measurement of the scattered polarized components with polarized incident light. Monochromatic light was obtained from a quartz prism monochromator and General Electric CH-3 mercury arc. An ultraviolet sensitive 1P28 photomultiplier tube served as a detector. A differential refractometer suitable for use at 3131 Å and employing photoelectric detection has also been constructed.

The RNA was prepared by heating virus which had been suspended in 0.1M sodium acetate plus 0.2M sodium chloride pH 5.7 buffer. This denatures and precipitates the

¹Doctoral thesis no. 1572, submitted July 4, 1954. Chairman of Committee, Robert L. Sinsheimer, Department of Physics.

²B.S., Allegheny College, Meadville, Pennsylvania, 1948. M.S., University of Rochester, Rochester, New York, 1951. Teaching Assistant, Physics Department.

protein, leaving the RNA in solution. These RNA solutions were cleaned for scattering measurements by centrifugation and filtration. Since the RNA would disintegrate at room temperature it was kept below 5°C at all times after preparation.

Consistent molecular weights of 1.7×10^6 could be obtained for initial virus concentrations of 5 to 20 mg/ml. However, the 20 mg/ml preparations required the addition of phosphate ion before heating to prevent aggregation of the virus during heating. This aggregation was evidenced by the production of RNA with molecular weight greater than 1.7×10^6 (30-40%). Measurement of molecular weight at both 4358\AA and 3131\AA gave values in agreement within experimental error. The refractive increment was 0.203 ml/gm at 4358\AA and 0.258 ml/gm at 3131\AA .

The characteristics of RNA were studied as a function of solvent salt concentrations from zero to 0.5M. Since the RNA was initially prepared in 0.3M salt, lower concentrations were obtained by dialysis. In water solution the RNA was shown to be a rigid rod $1620 \pm 100\text{\AA}$ in length. This length was calculated from dissymmetry measurements (the ratio of the scattered intensity at 45° to that at 135°). Data at both 4358\AA and 3131\AA provided an unambiguous interpretation that would not have been possible if only one wavelength had been used.

As the salt concentration was increased, the dissymmetry, hence the length, decreased and reached a constant value from 0.3M to 0.5M salt. The data can be explained with a rigid rod as a model but it is not as conclusive as in water. The alternative would be a kinked or bent rod, only not to the extent that it would be a random coil. The interpretation of a rigid rod leads to a length of $1050 \pm 100\text{\AA}$.

A correction to the length for anisotropy in polarizability of the rod was determined from depolarization measurements, but the correction factor was too large. It may be that the theory is not complete.

The RNA underwent a reversible aggregation (30% increase in molecular weight) as the salt concentration was increased from 0.3M to 0.5M. The molecular weight returned to its original value on decreasing the salt concentration showing reversibility. That the aggregation was side by side was demonstrated by the constant dissymmetry in this range. The molecular weight was independent of salt concentration below 0.3M.

The main evidence that this RNA of molecular weight 1.7×10^6 corresponds to all the RNA in one virus is its constancy over a fairly wide range of preparation conditions. Phosphorus analyses on the whole virus give an upper limit of 2.2×10^6 for the RNA molecular weight. The difference is not clear. The upper limit may be too large or the inherent enzyme may have caused some degradation of the RNA during cooling immediately after preparation.

The rod shape indicates that the virus probably consists of an inner core of RNA with the protein as an outer shell surrounding the RNA.

A STATISTICAL TECHNIQUE FOR ESTIMATING THE CHARACTERISTICS OF CONSUMER BEHAVIOR¹

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The investigation is concerned with an econometric technique for examining the classical theory of consumer choice and consists of the development of a stochastic model, the derivation of estimators of the unknown parameters in this model, the determination of the variances and covariances of these estimators, the derivation of estimators of important functions and parameters in the theory of consumer choice, and empirical results obtained using the above techniques.

The description of the theory of consumer choice given by J.R. Hicks in his book "Value and Capital" provides the basic economic theory in the construction of the stochastic model. The existence of a utility indicator is assumed, and the necessary

¹Doctoral thesis no. 1610, submitted December 3, 1954. Chairman of Committee, Gerhard Tintner, Department of Statistics.

²B.A., Carleton College, Northfield, Minnesota, 1951. M.S., Iowa State College, Ames, Iowa, 1953. Graduate Assistant, Statistics. Associate, Industrial Science Research Institute.

condition for consumer equilibrium is used. This condition is that the marginal rate of substitution between any two commodities equals the price ratios of these commodities. Assuming that there are n commodities, $n-1$ equations are obtained by equating the marginal rates of substitution to price ratios and the n^{th} equation is the condition that the consumer spends all of his income on the n commodities. The novelty of the mathematical model results from the assumption that the marginal rate of substitution between two commodities may be approximated by a linear function of the current quantities of the n consumption goods purchased and of time lagged real expenditure. This approximation injects stochastic elements into the model because the linear forms are justified on the basis of a series expansion and do not contain all variables which may be important. The mathematical system obtained consists of $n-1$ stochastic linear equations which are subject to a bilinear constraint. These $n-1$ stochastic linear equations are assumed to be subject to a multivariate normal distribution and the system of equations determines the quantities of the n commodities that a consumer will purchase.

The estimators of the unknown parameters in the model are obtained by using the transformed distribution of the dependent variables. Since the original system of equations is just identified, the reduced form equations may be used in the estimation process. The reduced form equations are subject to a multivariate normal distribution, and this may be approximated by a multivariate normal linear regression situation. The usual techniques of maximum likelihood are used to obtain the estimators of the regression coefficients in the reduced form equations. These point estimates give rise to the transformation matrix, and the estimates of the parameters in the original model are obtained by applying the estimated transformation matrix to the estimated reduced form equations. Point estimates of all the parameters in the original model are obtained by using the above techniques and these estimates have certain desirable properties since they are maximum likelihood estimates.

Since point estimates of the parameters in a model are not very meaningful without some measure of the possible error in the estimate, considerable attention is given to the determination of the variances and covariances of the estimated parameters. The estimated parameters in the reduced form equations are known to be subject to a multivariate normal distribution. The estimate of the variance-covariance matrix of this distribution is easily obtained. The variances and covariances of the estimators of the parameters in the original model are not well known. By considering linear error terms in the inversion of a matrix which is subject to error and examining the accumulation of errors when using this matrix to operate on other matrices which are subject to errors, approximate formulas for the variances and covariances of the estimated parameters in the original model are obtained. These variances and covariances are functions of the parameters in the model and the variance-covariance matrix of the estimates of the parameters in the reduced form equations, and so they may also be easily estimated. The distribution of the estimated parameters in the original model may be approximated by a multivariate normal distribution and this is justified on the basis of the asymptotic properties of maximum likelihood estimators.

This technique is designed to provide estimates of all the basic characteristics of consumer behavior and may be used for both descriptive and prediction purposes. The descriptive aspects involve the presentation of individual consumer demand equations, Engel curves, price elasticities, income elasticities, and empirical utility indicators. The estimated reduced form equations correspond to the individual consumer demand equations for the first $n-1$ commodities. The demand equation for the n^{th} commodity is obtained by using the bilinear income constraint. Since the variable income enters the demand equations in a linear manner, linear Engel curves are obtained by substituting the desired prices in the demand curves. Price and income elasticities are obtained by considering the partial derivatives of the demand equations. These derivatives may be evaluated for the desired values of prices and income and correspond to the absolute partial rates of change. The elasticities may be determined by reducing the absolute partial rates of change to relative partial rates of change. Since the marginal rate of substitution is the ratio of two partial derivatives of a utility indicator, the estimation of the parameters in the original model gives rise to an estimated set of partial differential equations. A general utility indicator may be obtained by finding an integral of this system of differential equations. Two integrals are presented and each of these is the result of a particular set of integrability conditions. A third type of integral may be obtained by applying Wald's approximate method to the linear Engel functions. The prediction aspects of the model consist of use of the estimated functions along with hypothetical values of price and income.

The above techniques were applied to the household expenditure records of 180 Iowa farmers during the period 1934 through 1942. The four generalized commodities, food, clothing, household operating and furnishings, and miscellaneous were considered in this analysis. All of the economic parameters and functions discussed in the previous paragraph are determined and are evaluated on the basis of their standard errors of estimate and economic meanings. About half of the estimated parameters and regression coefficients are established as being statistically significant and most of them have the expected economic characteristics. And so the results of this empirical investigation indicate that the technique is comparable to many of those which have appeared in the literature.

OPERATING CHARACTERISTICS OF A CENTRIFUGAL EXTRACTOR¹

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The operating characteristics of a Podbielniak Model 5000 centrifugal extractor having a combined-stream capacity of approximately 450 cc/min at 5000 rpm and a contacting section holdup of 529 cc were investigated. The variables studied--density difference, rotor speed, light-liquid-out pressure, holdup and flow rates--are both primary operating variables and important extraction variables.

A technique for holdup determination that comprises displacing either phase in the extractor with the other phase is described and experimentally demonstrated. Methods of obtaining the volumes of either phase in the rotor at flooding conditions are illustrated. Holdups of the various functional sections of the extractor are measured. The inventory of either phase in the rotor is shown to be a linear function of the light-liquid-out pressure.

The following relationship is experimentally verified for a single system:

$$P_{LLO} = \Delta \rho \frac{w^2}{g} (r^2 - V_{RHL} / \pi b) 2g_c$$

In this equation, P_{LLO} is the light-liquid-out pressure, $\Delta \rho$ is the density difference of the two liquids, w is the rotor speed, r is the rotor radius, V_{RHL} is the heavy-liquid inventory in the rotor and b is the rotor width. This equation permits the prediction of flooding limits and the light-liquid-out pressure required for a particular rotor inventory. Rather than use actual physical rotor dimensions in this equation, it is suggested that their effective numerical values be determined by the behavior of the extractor. The effective rotor width is estimated to be 0.174 in. and the rotor radius is estimated to be 7.71 in. These estimates are useful in applying this extractor to other systems. Rotor dimensions evaluated from the behavior of the extractor should permit application of this equation to other extractors of this type, independently of the internal arrangement of the contacting section. The effects of flow rates on this equation and on an equation useful in predicting light-liquid-in pressures are determined to be negligible for most practical purposes. The limitations in applying this equation to systems characterized by an appreciable change in density difference due to solute transfer are discussed.

A method of correlating number of stages, light-liquid-out pressure and flow rate is proposed and experimentally demonstrated by extracting boric acid from isoamyl alcohol with water. The useful feature of this correlation is that with a small number of laboratory runs one should be able to map in a family of curves for a particular system and thus rapidly estimate the optimum operating conditions for a given extraction problem.

A procedure is outlined for applying the techniques and methods developed in this investigation to other systems using similar extractors. The constants in the equation relating light-liquid-out pressure and rotor inventory are first estimated in order to

¹ Doctoral thesis no. 1604, submitted November 19, 1954. Chairman of Committee, G.H. Beyer, Department of Chemical Engineering.

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predict flooding limits. A small number of extraction runs are then made to estimate the optimum operating conditions for a particular system.

Some of the advantages of the extractor studied were small holdup, rapid attainment of steady-state conditions, and the ease with which flooding limits and rotor inventory may be predicted for various systems. A major disadvantage was the small flow rate ratio range compared to commercial units.

SOME SYNTHETIC STUDIES WITH DIBENZOFURAN¹

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In the past, certain dibenzofuran derivatives have been found to possess significant physiological activity. In the course of this investigation, attempts were made to incorporate the dibenzofuran nucleus in compounds structurally related to 5-nitro-2-furaldehyde semicarbazone (Furacin), isonicotinic acid hydrazide and chloramphenicol (Chloromycetin). Two dibenzofuran compounds chosen as goals were 3-nitro-8-dibenzofurancarboxaldehyde semicarbazone and 1-(3-nitro-8-dibenzofuryl)-2-dichloroacetamido-1,3-propanediol. Though neither of these compounds was obtained, a number of hitherto unreported intermediate compounds were prepared.

Treatment of 2-bromodibenzofuran with cuprous cyanide in quinoline solution at 180° gave a 79.1 per cent yield of 2-cyanodibenzofuran (1), m.p. 140-141°. This nitrile could be hydrated to the amide, m.p. 220-221° and hydrolyzed to the acid, m.p. 253-255° in good yield. 2-Dibenzofurancarboxamide was also prepared (91.8% yield) from 2-dibenzofurancarboxylic acid chloride. Bromination of 2-cyanodibenzofuran in acetic acid solution gave what appeared to be 2-bromo-8-dibenzofurancarboxamide, m.p. 277.5-278.5°, on the basis of the infrared spectrum. Hydrolysis of the bromo-amide in methanolic potassium hydroxide gave 2-bromo-8-dibenzofurancarboxylic acid (2), m.p. 334.5-336.5° dec.

Reduction of 2-cyanodibenzofuran with 0.25 mole of lithium aluminum hydride yielded no crystalline product; when an excess of the reagent was used, material having a m.p. range of 241-250° dec. was obtained. The infrared spectrum suggested the structure of an amine hydrochloride for this substance.

Treatment of 2,8-dibromodibenzofuran with cuprous cyanide under conditions used in preparation of 2-cyanodibenzofuran yielded 2,8-dicyanodibenzofuran (3), m.p. 304-305°. Alkaline hydrolysis of the dinitrile gave a nearly quantitative yield of 2,8-dibenzofurandicarboxylic acid (4), m.p. 440-442° (sublimes).

2-Bromo-7-nitrodibenzofuran (5), m.p. 251.5-253°, was obtained in 80.1 per cent yield on bromination of 3-nitrodibenzofuran. From the bromo-nitro compound was obtained 2-cyano-7-nitrodibenzofuran (identification by infrared spectrum), m.p. 247-249°.

The Friedel-Crafts reaction of dibenzofuran with oxalyl chloride gave a 29.4 per cent yield of crude 2-dibenzofurancarboxylic acid, m.p. range 243-251°. The crude ketone obtained on acetylation of dibenzofuran was converted to 2-dibenzofurancarboxylic acid, m.p. 250-253°, on treatment with alkaline hypochlorite solution. Fisher esterification of this acid yielded 57.1 per cent of the methyl ester (6), m.p. 81.5-82.5°. Treatment of the ester with hydrazine hydrate afforded a 67.7 per cent yield of 2-dibenzofurancarboxylic acid hydrazide, m.p. 210-212°. The latter compound was converted to the benzenesulfonhydrazide, m.p. 220-221.5°. From methyl 4-dibenzofurancarboxylate was obtained the hydrazide, m.p. 174-175° and benzenesulfonhydrazide, m.p. 242-243°. From methyl 2-bromo-6-dibenzofurancarboxylate was obtained the hydrazide, m.p. 198-200°, and the benzenesulfonhydrazide, m.p. 228-229°.

Bromination of 2-acetyldibenzofuran in ether solution at 0° gave a 12.7 per cent yield of 2-(ω -bromoacetyl)dibenzofuran (7), m.p. 105.5-106.5°. This compound could also be prepared by bromoacetylation of dibenzofuran with bromoacetyl bromide in the presence of aluminum chloride and treatment of the resulting mixture of phenacyl

¹ Doctoral thesis no. 1580, submitted July 14, 1954. Chairman of Committee, Henry Gilman, Department of Chemistry.

² B.S., Marquette University, Milwaukee, Wisconsin, 1949. Graduate Assistant, Department of Chemistry and the Industrial Science Research Institute.

bromide and chloride types with potassium bromide in acetone. Haloform oxidation of the mixture obtained in the bromoacetylation reaction followed by hypochlorite chlorination yielded an unresolvable mixture of halo-acids.

Crude 2-(ω -bromoacetyl)dibenzofuran was converted to its hexamethylenetetramine salt and thence, by treatment with hydrochloric acid in ethanol to 2-(ω -aminoacetyl)-dibenzofuran hydrochloride, m.p. 265-267° dec. Acetic anhydride in sodium acetate solution converted the amine salt into 2-(ω -acetamidoacetyl)dibenzofuran, m.p. 192-193°. Likewise, dichloroacetyl chloride gave 2-(ω -dichloroacetamidoacetyl)dibenzofuran, m.p. 167-169°. Hydroxymethylation of 2-(ω -acetamidoacetyl)dibenzofuran was unsuccessful.

Bromoacetylation of 3-nitrodibenzofuran using bromoacetyl bromide and aluminum chloride gave a mixture, m.p. 227-229°, the analysis of which indicated a 3:1 ratio of 2-(α -chloroacetyl)-7-nitro- and 2-(ω -bromoacetyl)-7-nitrodibenzofuran. This mixture yielded only a small amount of impure material on attempted conversion to the 2-(α -acetamidoacetyl)- compound.

Benzoylation of dibenzofuran with excess benzoyl chloride yielded both 2-benzoyl-dibenzofuran (8) (39.8%), m.p. 136-138° and 3.0 per cent of a dibenzoyldibenzofuran, presumably 2,8-dibenzoyldibenzofuran, m.p. 167-168.5°. The latter compound has been reported (9) as a benzoyldibenzofuran.

The oxime and dioxime melted at 158-159.5° and 231.5-232°, respectively. Beckman rearrangement of the monoxime gave 2-dibenzofurancarboxanilide, m.p. 164-165.5°, which could be hydrolyzed in sulfuric acid-acetic acid to 2-dibenzofurancarboxylic acid. Beckman rearrangement of the dioxime to give a pure product could not be accomplished.

2-Aminodibenzofuran and 2,8-diaminodibenzofuran were converted into the corresponding benzamides, m.p. 185-186° and 293-296°, respectively. From 4-dibenzofurancarboxylic acid chloride was prepared the anilide, m.p. 142.5-144.5°. The chloromethylation of dibenzofuran and Gattermann and Gattermann-Koch reactions with this heterocycle were unsuccessful.

Ethyl 2-dibenzofuranoxycetate, m.p. 54-54.5°, was prepared from 2-hydroxydibenzofuran and ethyl bromoacetate. Methylation of 3-acetyl-4-hydroxydibenzofuran gave a quantitative yield of 3-acetyl-4-methoxydibenzofuran, m.p. 69.5-70.5°.

Coincident with studies of the phytohormonal activity of dibenzofuran compounds, a number of aromatic compounds were prepared.

From toluhydroquinone and chloroacetic acid was obtained toluhydroquinonedioxyacetic acid (10), m.p. 212-213.5°. 4-Chlororesorcinol was chlorinated by treatment with sulfuryl chloride and the resultant 4,6-dichlororesorcinol (m.p. 112.5-113.5°) converted to the dichlorodioxyacetic acid, m.p. 226-228.5°.

Basic condensation of 2,4-dichlorophenol and trimethylene chlorobromide gave γ -(2,4-dichlorophenoxy)propyl chloride (11), b.p. 166-168° at 15 mm. When ethylene chlorobromide was used, β -(2,4-dichlorophenoxy)ethyl chloride (12), b.p. 155.5-156.5° at 16.5 mm, was obtained. A byproduct was bis-1,2-(2,4-dichlorophenoxy)-ethane (13), m.p. 133.5-134.5°.

Malonic ester condensation of γ -(2,4-dichlorophenoxy)propyl chloride gave, after hydrolysis and decarboxylation, δ -(2,4-dichlorophenoxy)valeric acid (11), m.p. 70-71°.

On malonic ester condensation and hydrolysis, β -(2,4-dichlorophenoxy)ethyl chloride gave β -(2,4-dichlorophenoxy)ethylmalonic acid, m.p. 125-128°.

Of the compounds tested for phytohormonal activity, only this substituted malonic acid showed activity, being one-tenth as active as 2,4-D.

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ELECTRICAL PROPERTIES OF COILS¹

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This dissertation concerns the variation of electrical resistance of conductors with frequency, especially of multilayer wire-wound coils. Two approaches were made, the one theoretical and the other experimental. Although the two approaches were not in complete agreement, evidence weighs heavily in favor of the theoretical development.

The basis of the theoretical approach was laid in the application of the Maxwell's equations to the generally accepted relationships of electrical circuits. Of the three approximations upon which low-frequency circuit theory rests, only one was retained for the scope of this study, namely, that the velocity of propagation is infinite. This assumption is the basis for the neglect of displacement currents in the dielectric media. The already well-established distribution equations follow from the combination of Maxwell's equations and the above assumption.

The magnetic field of a coil not too closely wound was assumed to be uniform throughout any cross section of the wire in the winding. By means of IBM facilities the magnetic field intensity was computed accurately on the wire axis of each turn in each of 35 selected coils. The expression for power loss in a unit length of an infinitely long circular conducting cylinder in a uniform transverse alternating magnetic field was used to determine the power loss in a single turn of the coil. These losses were summed over the entire coil for a selected group of frequencies and the corresponding ratios of a-c resistance to d-c resistance computed by IBM facilities. The 35 selected coils consisted of a master coil of 4 layers and 70 turns per layer and 34 smaller coils obtained as portions of the master coil. Thus, there were 20 single-layer coils having mean diameters equal to that of each layer in the master coil. There were 5 two-layer, 5 three-layer, and 5 four-layer coils having inside diameters equal to that of the master coil. Each group of 5 coils had 4, 8, 16, 32, and 70 turns per layer. As a check upon the results obtained, the theoretical values for the hypothetical case of an infinite number of turns were derived from the work of A.H.M. Arnold and S. Butterworth. Comparison of these values with those of this thesis for single-layer coils having finite number of turns showed satisfactory agreement.

The experimental approach consisted of the use of a Western Electric hybrid-coil impedance bridge. Although every known technique was used for obtaining maximum accuracy, the experimental results for the master coil yield similar but smaller values of the resistance ratio than those found by theoretical means. Inductance determinations from the same experimental data showed irregular but repeatable variations with frequency. Although no explanation was found for these variations, their existence was considered evidence of the faultiness of the experimental data. No other coils were tested because of the very low inductances with the consequent requirement of excessive amounts of tuning capacity.

¹Doctoral thesis no. 1581, submitted July 15, 1954. Chairman of Committee, W. B. Boast, Department of Electrical Engineering.

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RADIATION PATTERNS FOR SLOTTED CYLINDERS
OF ARBITRARY CROSS SECTION¹RALPH WALTER KLOPFENSTEIN²
Department of Mathematics

This study is concerned with a new approach to the problem of obtaining the current distributions and horizontal radiation patterns of slotted cylindrical antennas. An advantage over previous formulations is that this method can be applied to a rather wide class of cylinder cross sections whereas previous treatments have been restricted to circular and elliptic cylinders. Even in the case of circular and elliptic cylinders the method developed here yields numerical results for current distributions more economically than previous formulations.

The work done may conveniently be considered in two parts. The first of these deals with the mathematical formulation of the problem both as a partial differential equations problem and, alternatively, as a problem in linear integral equations. In this connection, theorems have been established as to the uniqueness and existence of solutions to the mathematical problem so formulated. The second part of the study deals with the development of practical methods of obtaining numerical solutions for particular cases typical of those arising in the practice of antenna design.

At the outset the problem is restricted to the case of an infinite cylinder with an infinite axial slot. The cylinder is taken as perfectly conducting except at the slot, and the electric field is assumed constant in the slot. For definiteness, the cylinder is specified by a curve σ in the XY plane of a three dimensional rectangular coordinate system and its generators are taken as parallel to the Z axis. The medium external to the cylinder is homogeneous and isotropic, and the field in the slot as well as all field quantities associated with the problem depend only on coordinates in the XY plane.

Starting from the basic assumption that all conduction currents on the infinite cylinder flow in a direction perpendicular to its axis, consideration of Maxwell's equations leads directly to the following two dimensional boundary value problem in partial differential equations:

$$\nabla^2 u + k^2 u = 0 \quad \text{external to } \sigma, \quad (1)$$

$$\frac{\partial u}{\partial n} = \text{a prescribed function } U \text{ on } \sigma, \quad (2)$$

$$\text{and} \quad \lim_{r \rightarrow \infty} \sqrt{r} \left\{ \frac{\partial u}{\partial r} - iku \right\} = 0, \quad (3)$$

where u represents the Z component of the magnetic field, k represents the propagation constant of the medium external to the cylinder, and r is the distance from a fixed point in the XY plane. In the case of slotted antennas, U is a rectangular function which is zero everywhere except for a narrow interval where it is constant.

The boundary value problem as stated by equations (1) through (3) is the point of view from which current distributions and radiation patterns have been obtained previously for slotted circular and elliptic cylinders through an expansion in complete sets of wave functions. In order to arrive at an approach suitable for more general cross sections, Green's theorem is utilized to obtain an integral equation for the current distribution on the cylinder.

When Green's theorem is applied to the region between the cylinder specified by the curve σ and an enclosing circular cylinder which can take on arbitrarily large radius, the integral relation

$$u(P) = \int_{\sigma} v(P, Q) U ds - \int_{\sigma} \frac{\partial v(P, Q)}{\partial n} u(Q) ds, \quad (4)$$

¹Doctoral thesis no. 1612, submitted December 6, 1954. Chairman of Committee, E. W. Anderson, Department of Mathematics.

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is obtained, P is a fixed point external to the curve σ , and Q is an integration point on the curve σ . $v(P, Q)$ is a unit source function defined by

$$v(P, Q) = \frac{1}{4\pi} H_0^{(1)}(kr_{PQ}). \quad (5)$$

The integrands in equation (4) are continuous for every point P external to σ since then rp_Q is greater than zero for every point Q on the curve σ . This is no longer true, however, when the point P lies on the curve σ . An investigation of the discontinuity properties of the integrals as the point P approaches σ leads to the integral equation

$$u(P_0) = 2 \int_{\sigma} v(P_0, Q) U ds - 2 \int_{\sigma} \frac{\partial v(P_0, Q)}{\partial n} u(Q) ds, \quad (6)$$

where P_0 is a fixed point on the curve σ .

Equation (6) is an integral equation for the current distribution on the curve σ . When the parametric equations

$$x = x(t), \quad y = y(t), \quad a \leq t \leq b, \quad (7)$$

are introduced for the curve σ , this integral equation can be written

$$u(t) = f(t) + \int_a^b K(t, \tau) u(\tau) d\tau, \quad (8)$$

which is a Fredholm type integral equation of the second kind in a single variable. The Fredholm theory of integral equations, in conjunction with a uniqueness theorem establishable from equations (1) through (3), assures the existence of a continuous solution $u(t)$ when the specified tangential electric field, U , is piecewise continuous.

The solution of the slotted antenna problem consists of obtaining the current distribution on the cylinder through the solution of the integral equation (8) and then extending that solution to all external points in space through the application of equation (4). In particular, the far field can be found from equation (4), and, for that case, it assumes a somewhat simplified form.

A major portion of the work in this study is concerned with the development of practical methods for obtaining solutions to the integral equation (8) for cases typical of those met with in antenna design. A number of approximation procedures have been applied to equation (8) for a particular case of the slotted circular cylinder, and the results have been compared with those obtained by the known solution for this case. An economical procedure results through the expansion of the kernel, $K(t, \tau)$, of the integral equation in an approximating finite double Fourier sum. The kernel so obtained is separable, and the resulting integral equation is directly solvable in closed form.

Additional applications to particular cases of the slotted elliptic cylinder and slotted square cylinder have been carried out. The integral equation formulation has been utilized to obtain the current distributions and horizontal radiation characteristics for these cases. In addition, experimental verification has been obtained through the construction of models and direct measurement of the horizontal radiation patterns. The agreement between calculated and measured patterns is quite satisfactory.

HISTOCHEMICAL LOCALIZATION OF CERTAIN CONSTITUENTS
OF THE DEVELOPING JUVENILE WING FEATHER¹ALICE LOUISE KONING²

Department of Zoology and Entomology

The development from a single follicle of a sequence of feathers which differ in their degree of morphological specialization is of considerable interest from the standpoint of tissue differentiation. A previous study was made on the histochemistry of the developing down feather in the hope of discovering something of the chemical basis of feather differentiation. The present work on the juvenile feather was carried out in order to further elucidate the functions of substances such as alkaline phosphatase, ribonucleic acid, and various polysaccharides in the production of a more advanced feather type.

Alkaline phosphatase was localized by the use of the Gomori method involving incubation with glycerophosphate. Ribonucleic acid was stained with toluidine blue, and its identity confirmed by digestion with ribonuclease to remove basophilia due to RNA. Polysaccharides were visualized both by their metachromasia and by the use of the periodic acid-Schiff (PAS) staining procedure. PAS-reactive material that was lost after digestion with saliva was identified as glycogen. Proteins were demonstrated by a mercuric chloride-bromphenol blue staining method. Disulfides were identified by their reaction with an alkaline solution of blue tetrazolium to give a blue color. Lipids were stained with Sudan black B.

After the completion of the down feather, which occurs in the wing primaries at about the thirteenth day of embryonic development, the juvenile feather begins to differentiate at the base of the follicle. Barb ridges appear between fourteen and fifteen days, the rachis forms dorsally about a day later, and further development of these structures then proceeds rapidly.

In the mesoderm, the chief changes are in the localization of phosphatase. From its presence in and below the pulp of the down feather, it becomes restricted to the pulp of the thirteen-day feather. There is a further upward shift of the lower limit of the enzyme activity, until, at nineteen days, no phosphatase remains in the dermal papilla at the feather base, whereas it is retained in the pulp. Protein accumulates on fibers and in the cells of the papilla during its formation. Polysaccharides reacting to the PAS stain are present throughout the papilla and pulp. Metachromatic mucopolysaccharide is also present, closely following the pattern of phosphatase in its localization, as in the down feather. Just above the papilla, granules of glycogen begin to form about the seventeenth day and become very abundant by the twenty-second day. Lipid-containing macrophages appear in the pulp starting at about seventeen days.

In the epidermis of the feather, the collar becomes clearly differentiated by the eighteenth day of development. It consists of a thickened epidermal ring at the base of the feather, from which all the epidermal cells of the follicle and feather are derived. Above the collar is the ramogenous zone, in which the epidermal cells give rise to barb ridges. The basal cells of the collar have phosphatase-positive nuclei until about the seventeenth or eighteenth day of development; at this time little activity remains except for the nuclei of the ventral ramogenous zone. There is considerable RNA in the cytoplasm of all the cells of the ramogenous zone, and this increases greatly during the formation and growth of the feather. The middle layer of cells, the sheath cells, lose their RNA, first from the center of the cell, then its periphery, as the cells flatten to form the definitive sheath. Protein corresponds closely to RNA in its distribution, except that the sheath cells do not lose their protein as they do their RNA during differentiation. Polysaccharide is not present in the epidermis except for a PAS-reactive basal membrane which lies at the inner edge of the stratum cylindricum, bounding it from the pulp. This membrane is very irregular in outline, especially in the region of the collar. It flattens out in the ramogenous zone, and tends to disappear except from between the barb ridges. Lipids are present in the form of small granules around the nuclei of the cells of the collar and ramogenous zone.

During the development of the barb ridges, alkaline phosphatase appears in the

¹Doctoral thesis no. 1664, submitted June 1, 1955. Chairman of Committee, Howard L. Hamilton, Department of Zoology and Entomology.

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basement membrane bounding the ridge and in the nuclei of the stratum cylindricum. The enzyme is most active at the time the barb is in the most rapid phase of differentiation. At this period, two lateral rows of cells, the barbule plates, are formed from the stratum intermedium. At the inner end of the ridge is a mass of undifferentiated cells, the barb stem cells, which will form the future body of the barb. As the rearrangement of the cells takes place, RNA is lost entirely from all but the barbule cells. They continue to accumulate RNA as they elongate, until they contain large amounts at their inner ends. This disappears as the barbule cells flatten out to form the completed barbule. Even before this increase in RNA, glycogen is accumulating in the barbule cells, beginning with those nearest the sheath and proceeding in towards the barb stem. The glycogen increases greatly in the cytoplasm as the cells elongate, but disappears shortly before the RNA when the cells start to flatten. Protein increases in the barbule cells when the RNA is at a maximum and the glycogen has begun to decrease, remaining in the barbule cells after their differentiation is complete.

In the barb stem, glycogen accumulates in the form of large granules as the medullary cells begin to swell; this occurs at about the same time that glycogen is lost from the barbule cells. Ribonucleic acid and protein are not very apparent in these cells, except for some staining of the cell wall.

The rhachis is made up laterally of fused barb ridges with a central component derived from the collar. Medullary cells resembling those in the barb ridges differentiate from the centrally located cells. They acquire glycogen later than the barbs, and have RNA and protein only in their cell walls. However, RNA is found abundantly in certain of the cells between the medulla and the sheath. Most of these cells later become medullary cells, but some contribute to the cortical layer. From these studies it would appear that alkaline phosphatase may have an intracellular chemodifferentiating function, especially in the collar and ramogenous zone, but its main role in the pulp would seem to involve transport and/or modification of raw materials passing into the feather epidermis. Ribonucleic acid appears connected with the synthesis of protein. Glycogen is also implicated in the latter function and seems to be particularly abundant in areas where keratinization will take place. Glycogen may also be utilized anaerobically to supply energy to cells in areas which have a poor blood supply. The neutral polysaccharide of the pulp would seem to aid in the support of the feather; the acid mucopolysaccharide may be involved with phosphatase in transport.

PREDICTION OF FILTRATION RESISTANCE BY COMPRESSION-PERMEABILITY TECHNIQUES¹

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Filtration resistance was investigated by compression-permeability test techniques on laboratory and commercial plant materials.

The laboratory compression-permeability tests were made on reagent grade calcium carbonate, commercial grade calcium carbonate, commercial grade barium sulfate and chemical pure titanium dioxide. The range of mechanical pressure (P_m) used was approximately 1 to 740 psi and the range of specific resistance (α_p) found for the four materials was approximately 10 to 10,500 Hr.²/lb. In general, increased mechanical pressure (P_m) resulted in decreased porosity (ϵ), increased specific resistance (α_p), and decreased particle size. No simple relationship of α_p or ϵ to P_m was found for the entire P_m range for all the materials. However, good representation was obtained for each material by the use of one or more relationships of the form $\alpha_p = c P_m^r$. Influences of agitation and repulping on α_p and ϵ were demonstrated. By using a differential analysis calculation on two sets of compression-permeability test data, the problems of apparatus calibration, which were complicated by cake septum interaction, were circumvented. This gave more realistic results than the use of empty apparatus calibration.

¹Doctoral thesis no. 1672, submitted June 3, 1955. Chairman of Committee, D.R. Boylan, Department of Chemical Engineering.

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Laboratory constant pressure filtrations were made on the four materials using the pressure range of 6.5 to 71.8 psi to provide actual values of specific filtration resistance for comparison with predicted specific resistance found by the compression-permeability tests. Filter permeability tests were also made but the results were usually found to be significantly higher than the actual resistance values.

Analysis of the compression-permeability test data gave predicted specific filtration resistance values which were generally in good agreement with the actual specific resistance values. Specific resistance predicted by use of the equation

$$\alpha_{\text{mean}} = \frac{\int_0^P \alpha_p d P_m}{P}$$

was found to be in better agreement with actual values than those predicted by the use of the equation

$$\alpha_{\text{avg.}} = P \int_0^P \frac{d P_m}{\alpha_p}$$

developed by other workers. Deviations of actual specific resistance from $\alpha_{\text{avg.}}$ are believed to be the consequence of assumptions made in the derivation of the $\alpha_{\text{avg.}}$ equation. "Scouring" may also be an important factor.

Comparison of specific filtration resistance for commercial rotary drum plant filtrations, laboratory constant pressure filtrations, filter permeability tests, and compression-permeability tests was made for the dewatering of a pearl cornstarch prefilter. The agreement was excellent, showing that filtration theory and laboratory tests can be satisfactorily correlated with industrial practice.

DEGRADATION OF AMINO ACIDS BY LACTOBACILLUS CASEI IN RELATION TO FLAVOR DEVELOPMENT IN CHEDDAR CHEESE ¹

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The ability of *Lactobacillus casei* to degrade amino acids was investigated in order to establish a possible role of amino acids as a source of energy for growth of this bacterium in Cheddar Cheese. *L. casei* strain 7 was selected for the study because of its ability to deaminate DL-serine. This strain also differed from some other strains in that it produced H₂S in a V-8 juice medium without added carbohydrate. Deamination studies were carried out at pH 5.4, a pH in the range of ripening cheese, and at pH 8.3, a pH selected as being optimum for other bacterial deaminases. Each deamination tube contained 1.0 ml of 0.1 M phosphate buffer, 0.5 ml of a 0.05 M solution of amino acid and 0.5 ml of a suspension of washed cells usually containing from 1-2 mg of bacterial nitrogen per 0.5 ml. Initially 37°C was selected as incubation temperature, but, after temperature studies on deamination of DL-serine had been conducted, this was changed to 52°C at pH 5.4 and 46°C at pH 8.3. The reactions were allowed to go on for 2 hours and were then stopped by addition of 0.5 ml of 25 per cent trichloroacetic acid, after which the cells were removed and the NH₃ distilled off and determined by Nesslerization.

Deamination studies of most of the common amino acids and some related compounds showed that *L. casei* strain 7 was capable of releasing NH₃ in considerable amounts from serine, asparagine, and cysteine. None of the other amino acids were deaminated to any extent. Deamination also resulted in increases of pyruvic and lactic acids. Phosphoserine was not deaminated. Release of NH₃ from asparagine was greatest in the alkaline range and release of NH₃ from cysteine probably at a maximum in the acid range. With regard to release of NH₃ from serine, temperature and pH studies revealed the possible existence of two enzyme systems capable of deaminating serine, one with optimum at 46°C at pH 8.3 and one with optimum at 52°C pH 5.4. Addition of

¹Doctoral thesis no. 1603, submitted November 19, 1954. Chairman of Committee, F.E. Nelson, Department of Dairy Industry.

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glucose to a growth medium without V-8 juice added resulted in decreases in serine deaminase activity of the cells and in production of H_2S in the medium. Addition of 2 per cent glucose completely inhibited H_2S production but not deamination of serine.

Anaerobic-reduced deamination conditions created by addition of 100 γ of cysteine to the 2 ml of buffer-substrate-cell mixture and gassing with nitrogen, stimulated deamination of DL-serine. Addition of 50 γ of either adenosine-5-phosphate or reduced glutathione resulted in reduced deaminase activity. With increasing physiological age the ability to release NH_3 from DL-serine increased under aerobic test conditions but decreased when the test conditions were anaerobic-reduced. However, more NH_3 was always released under anaerobic-reduced test conditions at similar physiological states. The difference was particularly large with comparatively young cells. Pasteurization of cells resulted in considerable decreases in release of NH_3 from DL-serine when tested under aerobic conditions, but the reduction in activity was much less under anaerobic-reduced test conditions. The stability of the serine deaminases was tested by growing a large culture of *L. casei* strain 7 to pH 5.0 and then dividing it in several subcultures. These were adjusted to different pH levels and stored at 50°F up to 96 hr. Enzyme activity was most stable in cells stored at pH 8.3 under aerobic conditions. When stored at pH 4.2, only a little enzyme activity was apparent.

Types of *L. casei* capable of producing H_2S in the growth medium and deaminating DL-serine were isolated from high quality Cheddar cheese, whereas types only capable of deaminating DL-serine were isolated from lower grade cheese. This could indicate a possible importance of H_2S -producing types in Cheddar cheese.

Six series of Cheddar cheese were made from pasteurized milk to investigate the possible importance of the ability of *L. casei* strain 7 to deaminate serine on development of flavor. DL-serine was added to the curd in two series in which cheese both with and without *L. casei* added were represented. The remaining four series all were inoculated with *L. casei* and in addition whey globulins, containing the acid phosphatase of milk, or potato phosphatase preparations were added to increase the phosphatase activity of the pasteurized milk in the pH range of the cheese. As a large part of the serine in casein is present as phosphoserine and as pasteurization resulted in a reduction of phosphatase activity at pH 5.4 of the milk it was reasoned that restoration of the acid phosphatase activity of the milk might increase ester phosphorus in the cheese and make more serine available. A reduction in available serine for energy for growth of lactobacilli in Cheddar cheese made from pasteurized milk compared to that made from raw, possibly could be the reason for lack of development of true flavor in such cheese. The cheeses were examined after 2 days and 1, 3 and 6 months for phosphatase activity at pH 5.4, numbers of lactobacilli, pH, protein breakdown, -SH groups and "free" H_2S , free amino acids and quality.

The results of the cheesemaking experiments were not conclusive. Addition of DL-serine to curd without *L. casei* added resulted in increases in the numbers of lactobacilli. Any beneficial effect addition of phosphatase preparations might have had on the lactobacillus populations was not reflected on the counts, probably because of the rather large initial inocula. The cheese with the highest relative concentration of "free" H_2S received the highest flavor intensity score at 6 months. Judging from the cheese with DL-serine added, cheese in which serine was available in relatively large amounts early in the ripening period and in which utilization apparently ceased between the third and sixth month contained more "free" H_2S at 6 months than cheese where less serine was available or utilization continued. This could be the reason why cheese with phosphatase preparations added contained more "free" H_2S at 6 months and were found to be slightly better than their controls.

Possible reasons for the decrease commonly encountered in the numbers of lactobacilli in Cheddar cheese after some months of curing were discussed, as was the possibility of phosphatase activity prior to pasteurization being of more importance in releasing ester phosphorus from casein than the acid phosphatase after the cheese is made.

These experiments showed that *L. casei* strain 7 was capable of releasing NH_3 from serine, cysteine, and asparagine. Serine especially and also cysteine were attacked at considerable rates at pH levels similar to those of ripening Cheddar cheese. Subsequent cheesemaking experiments demonstrated that these two amino acids possibly play an important part in development of Cheddar cheese flavor. Serine possibly serves as a substrate providing energy for growth of lactobacilli and cysteine as a source of H_2S , a compound which these experiments indicated possibly is important for the flavor of Cheddar cheese.

MEASUREMENT AND SIGNIFICANCE OF
TRANSPORT NUMBERS IN FUSED SALTS¹RICHARD W. LAITY²

Department of Chemistry

The concept of transport numbers in fused salts is discussed in the light of the inapplicability of the usual definition applied to electrolytic solutions. The lack of a solvent reference frame, with respect to which the mobilities of the ions are normally compared, necessitates employment of a microscopic definition, if the conductance of a molten electrolyte is to be divided into a sum of meaningful ionic conductances. Thus, the reference frame selected here consists of the large bulk of ions not involved in the conductivity process at any given instant, i.e., those ions which lack the necessary energy of activation for migration. The transport numbers are therefore the fractions of current carried by the migrating ions during electrolysis as measured with respect to this frame.

Attempts of previous workers to measure transport numbers in fused salts are reviewed with respect to their validity and significance. It is shown that, while a few of the papers present significant data, the failure of any previous investigators adequately to consider the nature of the quantities they were measuring has led in other cases to publication of completely useless or uninterpretable experimental results.

A cell for measuring the transport numbers of the ions in pure molten salts is described. It has two vertical electrode compartments separated by a porous glass membrane. The displacement during electrolysis of an air bubble in a capillary tube connecting the two compartments yields data which can be combined with known density data to calculate the transport numbers, assuming the simplest formulas for the current-carrying ions. The validity of the use of this cell is verified for PbCl_2 by showing the lack of dependence of the measured transport numbers on the chemical nature of the membrane, as well as by other experiments and theoretical considerations. A criterion for indicating the applicability of the method to other pure salts, based on the possible influence of the membrane on the experimental activation energy of conductivity, is proposed and its use demonstrated.

A cell for measuring transport numbers in mixtures of fused salts is described. The electrode compartments are again separated by a porous glass membrane. Results with this cell are found by using a suitable analytical procedure to determine the actual quantity of each ion transferred from one compartment to the other on electrolysis.

Application of the former cell to a number of pure fused salts is shown to yield the following experimental transport numbers for the negative ions: PbCl_2 - 0.76 at 565 and at 635°C; PnBr_2 - 0.65 at 500 and 0.67 at 600°C; TlCl - 0.49+ at 475, at 505, and at 525°C; AgNO_3 - about 0.24 at 225 and at 275°C. In a nearly equimolar AgNO_3 - NaNO_3 mixture, use of the latter cell is shown to indicate that the nitrate ion carries a negligible fraction of the current, while the maximum transport number of the silver ion is less than 0.67.

An experiment is proposed by which the latter cell might also be used to determine the extent to which complex ions carry current in molten salts. The procedure would involve placing labeled cation or anion in the appropriate compartment and measuring the quantity of labeled ion that moves in the opposite direction from the corresponding electrode. It is shown how such information, combined with that of the type assembled in the present work, may be of considerable use in the development of a theory of the liquid state.

¹Doctoral thesis no. 1668, submitted June 2, 1955. Chairman of Committee, Frederick R. Duke, Department of Chemistry.

²B.A., Haverford College, Haverford, Pennsylvania, 1950. M.S., *Ibid.*, 1951. Research Assistant, Department of Chemistry and Institute for Atomic Research.

INFLUENCE OF CERTAIN FACTORS ON GROWTH OF BACTERIA
IN REFRIGERATED DAIRY PRODUCTS¹WALLACE CLAYTON LAWTON²

Department of Dairy Industry

The longer times now commonly used in holding and handling dairy products have greatly increased the importance of organisms which grow at refrigeration temperatures. The purpose of this investigation was to elucidate some of the factors affecting the growth of organisms at low temperatures.

Eight organisms were chosen from among those isolated from 50 samples of commercially pasteurized milk after enrichment for 7 days at 3°C. Single colonies were picked and purified by three single colony isolations. On classification, seven organisms were found to belong to the genus *Pseudomonas* and one to the genus *Flavobacterium*. A ninth organism, *Pseudomonas fragi*, was obtained from the Iowa State College Dairy Bacteriology Laboratory Collection.

Growth curves for the *Pseudomonas* cultures in pasteurized milk indicated that they had growth rates at 21, 25, and 32°C which were similar to those of the organisms surviving the laboratory pasteurization. The *Flavobacterium* had a slight lag in the early stages of growth. Growth in sterile skim milk indicated that all *Pseudomonas* species had their optimum growth temperature in the range 21 to 32°C, while the *Flavobacterium* culture had its optimum growth at 10°C. Calculation of generation times for cultures grown in sterile skim milk indicated that the minimum generation time usually occurred in the first 24 hours when cultures were grown at 21, 25, or 32°C. When cultures were grown at 5 or 10°C the minimum generation time was found at the 24-48 hour or the 48-72 hour interval.

Cultures used for inocula were grown at various temperatures prior to use to see if variation in temperature of growth of inocula had any effect on growth curves obtained. Growth curves at 5, 10, and 25°C were similar regardless of whether the culture had been grown at 5, 10, or 25°C prior to use. This indicated that these organisms required little or no adaptation when moved from one temperature to another within the range of 5 to 25°C.

As the extent of contamination may vary widely, it was decided to test the effect of the size of inoculum on growth curves obtained. Three levels of inoculum were used, the lowest resulting in an inoculum of less than one organism per milliliter. The resulting growth curves showed essentially the same shape, separated only by the difference in the size of inoculum. On prolonged holding, all populations reached approximately the same level. This indicated that contamination, even by very small numbers of organisms, could result in rapid increase to high numbers.

When cultures used for growth studies were held for 3 hours at room temperature (about 23°C) either early or late during the first 24 hours of growth, there was a decrease in the length of time required for the transitional stage from lag phase to logarithmic phase. The effect was not persistent, as the treated samples rose parallel to the controls after the initial increase brought about by the treatment. A similar result was observed regardless of the time the treatment was applied.

Some cultures were subjected to partial heat destruction and growth curves obtained for the surviving organisms. It was observed that each culture had a somewhat different heat tolerance, so various times and temperature were required to obtain the desired level of survival. When holding of survivors was at 5°C, some cases were observed where the survivors dropped to a level where no viable counts were obtained during the 216 hour test period. In other cases, the lag period was extended for 72 hours or longer, followed by increase at a rate normal for cultures grown at 5°C. When holding was at 10°C the lag phase of the survivors was appreciably increased over the control cultures, followed by a rise parallel to the controls. When holding was at 25°C, only a slight increase in the lag phase was noted and the balance of the growth curve was similar to that of the control.

Tryptone Glucose Yeast Extract (Plate Count) and Tryptone Glucose Extract (T.G.E.) agars were compared for their ability to enumerate survivors of heat treatment. The

¹Doctoral thesis no. 1569, submitted June 29, 1954. Chairman of Committee, F.E. Nelson, Department of Dairy Industry.

²B.S.A., University of Saskatchewan, Saskatoon, Canada, 1950. M.Sc., Ibid., 1951. Graduate Assistant.

count per milliliter of survivors immediately after heating was always higher on the Plate Count agar. After holding the survivors in milk for 24-48 hours the counts of organisms were usually similar on both types of agar. This difference in counts at the initial period was thought to be due to some ingredient in the Plate Count agar which was not present in the T.G.E. agar or milk and enabled enumeration of higher numbers of survivors.

Survivors of heat treated cultures were plated on T.G.E. agar and plates were incubated at 5 and 25°C. The counts obtained at the two temperatures were very similar. It was concluded that 25°C was satisfactory for the enumeration of heat-injured organisms which grow at low temperatures.

Because of the extensive use of chlorine in the dairy industry, it was decided to check the effect of partial inactivation of a culture by chlorine. The various cultures required different amounts of chlorine to effect a killing which would leave a uniform survivor population. The growth of survivors was very similar to that of the control, so no pronounced effect on surviving organisms could be attributed to the action of chlorine.

Essentially no differences in counts were obtained when survivors of chlorine treatment were plated on Plant Count and T.G.E. agars.

The extent of proteolysis of three of the cultures was checked by measuring the amount of tyrosine and tryptophan released. The cumulative amount of the two compounds released differed greatly for the three cultures over a 288 hour test period. The rate of release was fairly constant throughout the period for each culture. Plate count did not increase greatly after tyrosine and tryptophan release began.

Probably one important reason for the prolonged lag phase encountered in the growth of psychrophilic bacteria in many commercial milk samples is the common use of heat treatment to destroy bacteria in dairy equipment. When the level of heating is not sufficiently high to kill all bacteria which can grow at refrigeration temperatures, the lag phase of survivors may extend for several days.

EVALUATION OF SACCHARIFYING METHODS FOR ALCOHOLIC FERMENTATION OF STARCHY SUBSTRATES¹

ALICE LEE²

Department of Chemistry

Alcohol is undoubtedly one of the most vital raw materials in the world's chemical industry. Fermentation of grains is generally a minor source of industrial alcohol, but during periods of increased alcohol demand, grain fermentation becomes of great importance. Utilization of surplus grains by fermentation to produce ethanol has been considered and discussed for many years. At present considerable interest has developed in the possibility of using surplus wheat for alcohol production. The wheat surplus continues to increase each year in spite of acreage control by government. Coupled with this surplus is a great demand for increased supplies of wheat gluten from which to make monosodium glutamate. For recovery of wheat gluten, the wheat must be milled to flour and the gluten separated. The starch slurry remaining is a suitable substrate for fermentation.

Starchy substrates, such as grains, must be converted to fermentable sugars, a process called saccharification, before alcoholic fermentation by yeast is possible. Barley malt, although it has been used for centuries, is relatively expensive and does not effect complete conversion of starch into sugars. Fungal preparations have been found to be efficient replacements for malt. Methods for the evaluation of saccharifying efficiencies of fungal preparations are therefore of economic importance in grain fermentations.

Five preparations of *Aspergillus niger* 337 mold bran were prepared to check the applicability of Reese's short starch fermentation test (1). Optimum level of each

¹Doctoral thesis no. 1679, submitted June 6, 1955. Chairman of Committee, L.A. Underkofler, Department of Chemistry.

²B.S., University of the Philippines, Quezon City, P.I., 1949. Graduate Assistant, Industrial Science Research Institute.

mold bran was determined experimentally and compared with the intercept values obtained from the graphical analysis of short starch fermentation data. No over-all correlation between intercept values and optimum levels could be found.

In the investigation to determine whether starch slurry could be fermented efficiently after separation of gluten, 0.05 normal sulfuric acid was found to be the concentration necessary for initial cooking. Comparative studies were made on wheat flour and starch slurry saccharified by malt, mold brans, and submerged culture.

Mold bran from Aspergillus niger 337 gave higher yield than mold brans from Aspergillus niger 330 and Aspergillus oryzae 38b. All the three mold brans investigated proved to be better than malt. Approximately 88 per cent of theoretical yields were obtained from both wheat flour and starch slurry saccharified by Aspergillus niger 337 mold bran. Wheat flour always gave better yields than starch slurry when saccharified by malt, or mold brans from Aspergillus niger 330 or Aspergillus oryzae 38b. Higher optimum levels of saccharifying agent were required for starch slurry than for wheat flour for maximum alcohol yields.

Saccharification by submerged culture of Aspergillus niger 337 gave better yields than by mold bran. About 92 per cent of theoretical yield was obtained from both starch slurry and wheat flour saccharified by submerged Aspergillus niger 337 culture.

Addition of ammonium salts to mashers saccharified by either optimum or less than the optimum levels of saccharifying agents did not increase the alcohol yields appreciably. Decreases in yields were observed at higher concentrations of ammonium salts.

No evidence of the presence of inhibitor was found in either extracted or unextracted germ. Addition of unextracted germ resulted in increase in alcohol yields for both starch slurry and wheat flour saccharified by either malt, mold brans, or submerged cultures. In general, addition of unextracted germ showed increasing yields up to a certain concentration of germ, after which the yields leveled off with the addition of more germ. Highest alcohol yield (95 per cent of theoretical yield) was obtained from starch slurry saccharified by optimum volume (20 volume per cent) of submerged Aspergillus niger 337 culture with the addition of 1.5 g of unextracted germ per 300 ml of starch slurry. Alcohol yield higher than control was obtained from starch slurry saccharified by less than optimum level (15 volume per cent) of submerged Aspergillus niger 337 culture with the addition of 2 g of unextracted germ per 300 ml of starch slurry.

A steady decrease in alcohol yields was observed with increasing amount of ground whole wheat added, when the ground whole wheat was partly substituted for wheat flour. Very low alcohol yields obtained from ground whole wheat fermentations indicated the presence of inhibitor which must have been removed or destroyed during milling or storage of the germ.

Addition of vitamins (thiamine, inositol, pyridoxine, pantothenic acid, niacin, riboflavin, and folic acid) present in germ either alone or as a mixture did not increase the alcohol yields appreciably. Hence, these vitamins cannot account for the increase in yield observed when unextracted germ was added.

Evaluation of the mold brans and submerged culture by Reese's intercept method from the wheat fermentation data did not show any correlation between the intercept values and the optimum levels of saccharifying agents required for maximum alcohol yield. Although graphical analysis gave straight lines for all mold preparations on all the three different substrates, the straight lines were not all parallel.

The results of this investigation have shown that starch slurry can be fermented efficiently after the removal of gluten when saccharified by submerged culture of Aspergillus niger 337. Whether addition of unextracted germ is desirable or not will depend on the relative values of alcohol and germ.

Reese's intercept method cannot be used to compare preparations produced by different mold strains nor by the same strain cultures in different manners.

REFERENCE

1. Reese, H.D., E.I. Fulmer, and L.A. Underkofler. Evaluating fungal amylolytic materials for saccharifying fermentation mashers. Anal. Chem. 20:348-353. 1948.

AN INDICATOR ELECTRODE FOR METAL IONS¹

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The potentiometric determination of hydrogen ion concentration can be carried out very precisely by means of the hydrogen electrode, the quinhydrone electrode or the glass electrode. Similar means for the determination of metal ion concentration, particularly in the region of very small metal ion concentrations, are badly needed. The determination of the trace concentrations of the many metals which occur in biological fluids, as well as the study of complex-ion equilibria, would be greatly facilitated if means were available for the potentiometric measurement of small concentrations of metal ions.

In this work, an indicator electrode for metal ions analogous to the quinhydrone electrode for hydrogen ions is described and tested. The method is based upon the reversible oxidation-reduction behavior of the couple, 5,8-quinolinediol (H_2Q)-5,8-quinolinedione (Q), the formation of insoluble metal chelate compounds ($M(HQ)_2$) by 5,8-quinolinediol, and the formation of an insoluble quinhydrone, 5,8-quinolinehydrone (H_2Q_2). The preparation of these compounds is described, and the previously unreported 5,8-quinolinehydrone is characterized.

According to the theory developed, the potential of the cell



the chemical reaction for which is



is shown to be related to the metal ion concentration of the solution by the equation

$$(1) \quad E = E_o' + RT/2F \ln (M^{++}).$$

E_o' is defined by the equation

$$(2) \quad E_o' = E_o^{\circ} Q, H_2Q + RT/2F \ln K_2/K_1,$$

where K_2 and K_1 are the solubility products for the equilibria



respectively.

The electrode has been tested in solutions of nickel perchlorate well buffered with respect to pH. Measurements were made by saturating the buffered nickel perchlorate solutions (pH 6) with nickel bis-5,8-quinolinediol and 5,8-quinolinehydrone and measuring the potential of a platinum-saturated calomel electrode (S.C.E.) pair immersed in the solution. The potential is a linear function of pNi in the range pNi 3.0 to 4.2. At pNi greater than 4.2 the electrode fails due to the solubility of nickel bis-5,8-quinolinediol; for pNi smaller than 3.0 the electrode fails, presumably because of the formation of basic salts of nickel.

The value of $E_o^{\circ} Q, H_2Q$ has been determined from measurements of the potentials of a hydrogen electrode-S.C.E. and 5,8-quinolinehydrone electrode-S.C.E. in a series of buffer solutions. The value so obtained is +0.281 volts vs. S.C.E.

The solubilities of nickel bis-5,8-quinolinediol and 5,8-quinolinehydrone have been determined and values of K_1 and K_2 , respectively, have been calculated. Nickel bis-5,8-quinolinediol was determined by analyzing a portion of the saturated solution for nickel colorimetrically; the concentration of 5,8-quinolinehydrone in the saturated solution was measured polarographically. The values calculated are: $K_1 = 0.16$ and $K_2 = 9.10 \times 10^{-8}$.

¹ Doctoral thesis no. 1669, submitted June 3, 1955. Chairman of Committee, Harvey Diehl, Department of Chemistry.

² B.S., St. Louis University, St. Louis, Mo., 1951. M.S., Iowa State College, Ames, 1953. Graduate Assistant, Department of Chemistry and Industrial Science Research Institute.

E°_{Q, H_2Q, K_1} and K_2 were combined as indicated in equation (2) and the value of E°_1 obtained is +0.097 volts vs. S.C.E. The value of E°_1 obtained by extrapolating the experimental EMF-pNi graph to unit concentration of Ni^{++} is found to be +0.098 volts vs. S.C.E., in good agreement with the calculated value. The slope of the experimental EMF-pNi graph is -0.0306, also in good agreement with the theoretical value of -0.0295.

The literature pertaining to the quinhydrone electrode has been briefly reviewed.

MEASUREMENT OF THE IONIZATION YIELD OF LOW ENERGY ATOMIC PARTICLES IN GASES¹

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The purpose of this investigation was to study the total ionization yield of charged atomic particles in gases for energies in the range of a few to 250 kev. A large cylindrical ionization chamber was used for this study. The charged particles were selected from the kevatron beam by a magnetic and an electrostatic analyzer and entered the chamber by means of a 0.004 inch diameter open window. A differential pumping system permitted pressures up to 10 mm Hg to be maintained in the chamber. The chamber was alternately operated as a proportional counter and an ionization chamber to measure the rate with which the primary ions entered the chamber and the ionization produced by them, respectively. A detailed description of the apparatus and measuring technique is given.

The ionization yields of protons in nitrogen were measured as a preliminary test of the feasibility of the experimental method and to check the performance of the apparatus. The results of these measurements were subject to large uncertainties, but indicated a straight line relation between ionization yield and energy for energies above 75 kev. The slope of the line corresponded to 36.6 ev/ip.

More precise measurements were made of the ionization yield of protons in argon. The results indicated that any deviation from a linear relation between ionization yield and energy was small for energies above 25 kev. The slope of a least squares plot of the data corresponded to 26.5 ev/ip. The straight line representing the least squares plot intercepted the energy axis at 1.4 kev indicating a slight ionization defect for protons in argon.

It was concluded that the apparatus and measuring technique had proven to be relatively successful and perhaps adequate to continue with an investigation of more interesting combinations of ions and gases.

¹Doctoral thesis no. 1653, submitted May 18, 1955. Chairman of Committee, Glen Miller, Department of Physics.

²B.S., Iowa State College, Ames, 1949. Research Assistant, Institute for Atomic Research.

RELEASE OF NONEXCHANGEABLE SOIL POTASSIUM ON DRYING¹RALPH E. LUEBS²

Department of Agronomy

The purpose of this investigation was to determine the relation of exchangeable K to variations in soil moisture content and to study the significance of this relationship with respect to correlating amounts of exchangeable K in soils with the amounts of K available to plants.

Results showing the relation of exchangeable K level to moisture content in Iowa soils may be summarized as follows:

1. Samples of a Harpster silty clay loam originally containing 144 pounds exchangeable K per acre and 4.4 per cent moisture, when stored in dessicators at 10 per cent and 90 per cent relative humidity finally reached equilibrium levels of 200 and 95 pounds exchangeable K, respectively. Corresponding moisture levels in the soil at equilibrium were 2.3 and 7.5 per cent. Interchanging samples of the Harpster soil with respect to vapor pressure, resulted in an almost complete reversal of exchangeable K levels to those previously attained under like conditions.

2. Air drying 13 Iowa soils from the field moist state at room temperature for 24 hours resulted in increased levels of exchangeable K ranging from 26 to 122 pounds per acre. In five of the soils K levels were more than doubled due to drying.

3. In studying the relation between exchangeable K and soil moisture level throughout the range from field moist to completely air dry, it was found that drying exerted little or no effect until moisture content of soils had dropped to 10 per cent or less. Sharp increases in exchangeable K occurred when soils' moisture content fell below five per cent. Oven-drying at 100°C usually resulted in further increases of exchangeable K over those attained during air drying at room temperature.

4. When air dried soils were moistened to field capacity, a marked reversion of K to nonexchangeable forms occurred in the Harpster and Webster soils within 10 days. In other soils, reversion took place more slowly, if at all.

On the basis of these findings it is concluded that the "equilibrium" level of exchangeable K in soils must be defined in relation to the moisture status of the soil. Since the reversibility of exchangeable K levels with alternating periods of moist and dry conditions has been clearly demonstrated, it can now be stated that for certain soils an equilibrium exists among exchangeable and nonexchangeable forms of K.

Thirteen field moist Iowa soils were cropped to corn in the greenhouse after receiving different levels of K fertilizer. A portion of each soil was also dried and cropped without applied K. Major findings based on exchangeable K studies of the soils and measurements of K uptake by the plants are summarized as follows:

1. Increased in exchangeable K content of soils upon air drying resulted in greater K absorption by the plants than occurred from the undried soils. These increases in exchangeable K were equivalent to applications ranging from 15 to 120 pounds K per acre.

2. Yield of K (yield of dry matter \times per cent K in plants) was linearly related to rate of K application on 11 of the 13 soils. Linear regression equations of the type $y = mx + b$, where y = yield of K, x = rate of K applications, m = slope, and b = "y" intercept were calculated. Letting $y = 0$, the equations derived for each soil were solved for "x". This value of "x" was designated as the "K-value" which is defined as the quantity of available soil K possessing the same availability as that of the applied fertilizer. These values were highly correlated with exchangeable K content of undried soils ($r = 0.891$).

3. Method of conditioning soil samples prior to determination of exchangeable K exerted a marked influence on the relation between exchangeable and K uptake by plants. Correlation coefficients expressing this relationship for the field moist soils and the soils which were dried before cropping were calculated. It was found that: 1) K uptake from field moist soils was better correlated with exchangeable K of undried ($r = 0.964$) than of air dried samples ($r = 0.726$). 2) K uptake from soils dried before cropping also was better correlated with exchangeable K content of undried ($r = 0.875$)

¹Doctoral thesis no. 1616, submitted December 8, 1954. Chairman of Committee, George Stanford, Department of Agronomy.

²B.Sc. University of Nebraska, Lincoln, Neb., 1948. M.Sc. Ibid., 1952. Graduate Assistant.

than of dried soils ($r = 0.786$). 3) Where soils were air dried and then rewetted for 43 days, exchangeable K values correlated highly with K uptake from undried soils ($r = 0.929$) as well as from dried soils ($r = 0.980$).

Thus, it is clear that soils should not be dried prior to determination of exchangeable K where such values are to be used in predicting the relative K-supplying abilities of soils.

4. Small variations in the abilities of the soils to fix applied K under moist conditions appeared to exert little or no influence on the degree of correlation obtained between exchangeable K and K uptake or response to applied K.

5. Wide variations in the Ca plus Mg:K ratios in plants from the soils which received no K fertilizer exerted no effect on the relationship between exchangeable K and K uptake by plants.

In agreement with results obtained by drying soil in the laboratory, studies showed that appreciable K release in the field occurred only when soils were dried to low moisture contents. Over a prolonged dry period, the release of K in the field was evident only in the surface inch of a Clarion and a Harpster soil. On the basis of this limited study it is concluded that increase in available K resulting from drying occurs only in a small volume of the soil which would be occupied by plant roots and, therefore, may be of little significance in supplying the K needs of plants during a particular season. Further studies are needed on this aspect of the K problem, in view of the practical implications involved not only with respect to K nutrition of plants, but also the problem of predicting K fertilizer needs based on exchangeable K determination.

A BIOLOGICAL SLOPE-RATIO METHOD FOR EVALUATING NUTRIENT AVAILABILITY IN SOILS¹

CHARLES BERNARD MC CANTS²
Department of Agronomy

The objective of this investigation was to investigate the applicability of the slope-ratio principle used in biological assay to evaluating relative availabilities of nutrients in different soils. The reason for undertaking the work was that most plant-response methods for evaluating nutrient availability involve application of a fertilizer source of the nutrient and assuming that the availability thereof is the same in all soils. Since the assumption is probably invalid, the results are probably biased. The slope-ratio method does not involve addition of fertilizer, and therefore eliminates a potential source of error inherent in most other methods.

The experimental technique employed was to grow plants in sand cultures in which nutrients other than the one being assayed were supplied in ample quantities. In one series of sand cultures increasing quantities of a soluble salt of the nutrient were applied and in another series increasing quantities of soil were applied. The quantities of soil were kept small, so as to minimize effects of differences in physical and chemical properties other than the nutrient being investigated. The results of such an experiment can be represented by curves showing the plant response to rates of application of soil or of nutrient. When the response curves are linear, and there is no evidence of differences in response resulting from factors other than availability of the nutrient, the ratio of regression coefficients gives an estimate of the relative availability of the nutrient in different soils.

A special experiment was designed to test the validity of the slope-ratio method for estimating relative availabilities of a particular nutrient in different soils. In this experiment, sand-soil cultures were prepared by adding 0, 300, 600, and 900 grams of soil per culture of 4000 grams of sand-soil mixture. Nitrate nitrogen was added at rates of 0, 2, and 4 milligrams of nitrogen per 100 grams of soil. Equivalent quantities of nitrate nitrogen were added to pure sand cultures. This experiment provided three tests of validity of the slope-ratio method: 1) equality of yield of dry matter vs.

¹Doctoral thesis no. 1646, submitted March 31, 1955. Chairman of Committee, C.A. Black, Department of Agronomy.

²B.S., North Carolina State College, Raleigh, N.C., 1949. M.S., Ibid., 1950. Graduate Assistant.

yield of nutrient relationships, 2) similarity of response-dose relationships, and 3) ratios of regression coefficients under conditions of known availability ratios.

Analysis of the data showed no evidence that the relationship between yield of dry matter and yield of nitrogen in the plants differed between soils, but there was a difference between the sand-soil cultures and the sand cultures. The yield of dry matter per unit of nitrogen in the plant was greater with sand-soil cultures than with sand cultures. The results of this test indicated valid estimates of relative availability of nitrogen could be made in the sand-soil cultures, but that comparisons between the sand-soil cultures and the sand cultures would probably be biased.

Yield of dry matter and yield of nitrogen were linearly related to rates of nitrogen applied to both sand and sand-soil cultures. The extrapolated response to zero application of nitrogen or soil did not differ appreciably between soils, but differed significantly from the values observed in the sand cultures. This evidence indicates that estimates of relative nitrogen availability would be valid within the sand-soil cultures, but not between the sand-soil cultures and the sand cultures.

Since there is no significant evidence of deviation of observed responses in the sand-soil cultures from the model of concurrent straight lines intersecting at zero dose, this model was used to represent the responses. The hypothesis was then examined that $\frac{b_4 - b_0}{b_2 - b_0} = 2$, where b_0 , b_2 , and b_4 are, respectively, regression coefficients for rates of soil containing 0, 2, and 4 milligrams of added nitrogen per 100 grams of soil. When yield of dry matter and yield of nitrogen were employed as criteria of response, the observed ratios $\frac{b_4 - b_0}{b_2 - b_0}$ did not differ significantly from the theoretical ratio of 2. These results lend support to the validity of the slope-ratio method for estimating relative availability of a nutrient in different soils.

Application of the slope-ratio method was further investigated in an experiment with phosphorus. The soil samples employed were taken from field plots that had previously received limestone at two different rates (soil pH values were about 5.5 and 6.5). The soil samples were treated with 0 and 1.725 milligrams of labeled phosphorus, as monobasic sodium phosphate, per 100 grams of soil and the resulting samples were incorporated with sand at rates of 0, 200, 400, and 600 grams of soil per 4000 grams of sand-soil mixture.

Examination of the results showed that the yield of dry matter per unit of phosphorus in the plant was usually greater in cultures of low-lime soils than in cultures of high-lime soils. This condition would probably be associated with a bias in estimates of relative phosphorus availability in favor of the low-lime soils. Because of this evidence, no attempt was made to calculate the relative availabilities of phosphorus as affected by field liming treatments. The absolute responses, however, were usually smaller in samples taken from the high-lime plots than from the low-lime plots. The opposite behavior is found in the field.

The availability of fertilizer phosphorus in sand-soil cultures relative to that in sand cultures was calculated for a few samples for which the yield of dry matter vs. yield of phosphorus curves did not differ significantly. The availability of fertilizer phosphorus in the soil as a fraction of that in sand was found to be about 0.16. This value indicates the degree to which availability of fertilizer phosphorus was reduced when placed in contact with soil.

The results from other soils and experiments with phosphorus were similar to those just described. The evidence indicated that inferences about relative availability of phosphorus in the different soils would probably be biased. The magnitude of the bias is unknown.

In cases where there is evidence from the yield of dry matter vs. yield of nutrient functions that slope-ratio estimates of relative nutrient availability would be biased, it is not clear whether the slope-ratio method has any advantages over other methods. When all methods give biased results, the comparative value of the various methods can be determined only by trial.

EFFECTS OF INBREEDING ON MORTALITY IN THE DOMESTIC FOWL¹DONALD WAYNE MAC LAURY²

Department of Poultry Husbandry

A rapid increase in the commercial production of hybrid (incrossbred) chickens the past few years makes a more complete knowledge of the influence of inbreeding on reproductive performance most important. Factors of reproductive performance are fertility, hatchability, rate of egg production, and viability. This study was concerned with viability, or mortality.

U.S.D.A. figures indicate an increase of over a half-million birds in incrossmated flocks over the two-year period from 1951-1952 to 1953-54. Total numbers in these flocks in 1953-54 were nearly two million. These would have parents with inbreeding coefficients of 50 per cent or more.

Previous studies of inbreeding have demonstrated an inbreeding depression effect on all phases of reproduction. The specific problem reported here was the relationship of inbreeding to mortality, freed as much as possible from the effects of years, lines, and interactions of the two.

Records of 25 inbred lines of Leghorn stock from the Iowa Agricultural Experiment Station were studied for the 15-year period from 1932 to 1947, inclusive. The stock included three strains developed at the Iowa Station, three lines introduced from other experiment stations, two lines from commercial sources, and one from England. Inbreeding coefficients varied from zero to 83 per cent.

The lifetime of the bird was divided into three periods. The brooder period extended from hatching to eight weeks of age, the range period from eight weeks to housing, and the laying-house period from housing to the following July 1. In these three periods, mortality records were studied for 30,578 chicks, 10,492 pullets sent to range, and 7,441 pullets housed from the inbred birds. In one phase of the study, corresponding observations were made on noninbred Leghorns serving as controls, which included 16,275 chicks, 4,919 pullets sent to range, and 4,103 pullets housed.

As a preliminary study, a simple linear regression of mortality on inbreeding class centers was calculated using nine classes grouped by 10 per cent intervals. By this method the effects of lines and years as sources of variation were ignored. The following regression coefficients were obtained: 0.23 ± 0.05 for brooder mortality, 0.15 ± 0.04 for range mortality, and 0.43 ± 0.03 for laying-house mortality. There existed the possibility that mortality might have been associated with years. If this were true the time trend would be confounded with the estimate of inbreeding effect, so that the regression estimates could not be considered unbiased. To investigate this question, regressions of mortality on years, disregarding lines and inbreeding, were calculated. Values for both inbreds and noninbreds were found to be nonsignificant. This indicated that a time trend in mortality was not important.

As a second method, the inbreeding and mortality of inbred line-year subclasses were corrected through the use of values found in the "noninbred" control flock. Since the noninbreds were maintained largely as a closed flock, some slight inbreeding resulted. This inbreeding was subtracted from that of the inbred lines in corresponding years. Yearly variations in mortality among the noninbreds were used similarly to correct inbred mortality values. The corrected values were then used to calculate regression of mortality on inbreeding. This method thus offered some degree of correction for yearly deviations in mortality, but did not correct for line differences. Regression coefficients obtained were 0.25 ± 0.05 for brooder mortality, 0.20 ± 0.06 for range mortality, and 0.35 ± 0.07 for laying-house mortality.

The principle of least squares was used as a third method to estimate the regression of mortality on inbreeding. By this method extraneous effects of lines, years, and line-year interactions can be separated from the inbreeding regression effect. Regression coefficients obtained were 0.33 ± 0.04 for brooder mortality, 0.15 ± 0.05 for range mortality, and 0.21 ± 0.04 for laying-house mortality.

Reductions in sum of squares due to estimating parameters by the least squares method yielded highly significant values for lines, years, and line-year interactions

¹Doctoral thesis no. 1651, submitted May 5, 1955. Chairman of Committee, A.W. Nordskog, Department of Poultry Husbandry.

²B.S., Cornell University, Ithaca, New York, 1937. M.S., Iowa State College, Ames, Iowa, 1940.

in all three mortality periods. In addition, the relative influence of these effects was estimated by means of components of variance. Line variance was found to be much larger than either year or line-year variance. Line-year variance was slightly larger than year variance. The line, year, and line-year effects accounted for 84, 5, and 10 per cent of total variance, respectively.

Studies over the combined brooder, range, and laying-house periods indicated that the regression of mortality from hatching to July 1 of the pullet year on inbreeding was approximately 0.55. Regression coefficients by all methods were positive and differed significantly from zero. When regression coefficients for the same mortality period were compared by means of the "t" test, no significant differences were found between the second and third methods, although smaller standard errors were obtained using least squares procedures (third method).

Estimates were made of the relative effects of inbreeding and selection on viability. Under certain specified conditions (heritability = 0.1, 20 per cent truncation selection, 20 per cent expected mortality, regression of mortality on inbreeding 0.33) genetic gains from selection were estimated to offset a 10 per cent increase in inbreeding. Under the same conditions, except when regression is 0.15, selection would offset a 20 per cent increase in inbreeding.

Costs of inbreeding were estimated on the basis of regressions found in this and other studies. The estimates demonstrated a nonlinear increase in costs with increased inbreeding. Inbreeding costs were one and a half times noninbred costs when inbreeding was 50 per cent. As inbreeding approached 100 per cent, it was estimated that the cost increased to about four times that of noninbreds.

A possible physiological effect of inbreeding on reproductive performance in the fowl was discussed. It was suggested that certain characteristics of inbreds indicated a depression of thyroid activity. Suggestions were made with regard to changing the environment to improve the performance of inbreds.

CHROMATOGRAPHY AND RESIDUE ANALYSIS OF AN ORGANIC PHOSPHATE INSECTICIDE (DEMETON)¹

WILLIAM J. MAGEE²

Department of Zoology and Entomology

Bioassay with the green peach aphid, *Myzod persicae* (Sulz.), and the red spider mite, *Tetranychus bimaculatus* Harvey, was used to indicate incorporation of demeton by bell pepper plants. The insecticidal activity of demeton was very effective in reducing populations of these species. Reversed phase paper chromatographic separations are reported for extracts of these plants and the insecticide, demeton. Analyses for phosphate and the mercaptans liberated by hydrolysis were used to locate and prove the structure of the compounds resolved by chromatography. Phosphate analyses of resolved compounds on chromatographs showed that the demeton sample used for study was a mixture of 20.2 per cent O, O-diethyl O-2(ethylmercapto)ethyl thionophosphate (I), 54.9 per cent O, S-diethyl O-2(ethylmercapto)ethyl thiophosphate (II) and 24.1 per cent O, O-diethyl S-2(ethylmercapto)ethyl thiophosphate (III). Iodometric analyses of the mercaptans liberated by alkaline hydrolysis gave similar values for the thiophosphate esters (II and III). Base titration of the sulfuric acid formed by acid hydrolysis of thionosulfur gave similar results for the thionophosphate ester (I). Residue analyses of resolved plant extracts indicated that the only active material in mature bell pepper plants the first week after treatment was probably unchanged O, O-diethyl S-2(ethylmercapto)ethyl thiophosphate (III). The need for additional investigation was expressed.

¹Doctoral thesis no. 1650, submitted April 22, 1955. Chairman of Committee, G.H. Richardson, Department of Zoology and Entomology.

²B.S., Agricultural and Mechanical College of Texas, College Station, Texas, 1949. M.S., *Ibid.*, 1950. Graduate Assistant, Agricultural Experiment Station.

FACTORS AFFECTING GROWTH RATE OF DAIRY CALVES¹TRUMAN G. MARTIN²

Department of Animal Husbandry

Over seven million dairy calves are raised annually by American farmers. This fact has led research workers to study the adequacy of various dietary and managerial regimes for raising dairy calves. Adequacy has been judged most often by growth response. The object of this study was to evaluate some of the factors affecting growth response.

Available body weight data to 1 year of age on 659 dairy calves which had been on nutrition experiments were used in this study to evaluate the effects of breed, sex, ration, season of birth, and birth weight on growth of dairy calves. Relationship of birth weight and body weight gain to age at calving and to milk production in the first lactation were estimated also.

Sex, breed, season of birth, and ration effects were estimated by the technique of fitting constants and computing an analysis of variance. Birth weight effects on growth were estimated by correlation of birth weight with gains from birth to various ages ranging from 2 weeks to 1 year. Relationship of birth weight and growth to age at calving and to production were estimated by correlation coefficients.

Male calves were found to be heavier than female calves at birth and to gain faster than female calves from birth to 8 weeks, birth to 6 months, and birth to 1 year of age. The sex effect on gain was partially dependent on sex difference in birth weight, but there was a true sex difference independent of birth weight. Similarly, the 6-month gain was partially dependent on 8-week gain, but not enough to remove significance. All sex differences, both adjusted and unadjusted, were significant ($P \leq 0.01$).

Breed effects were present in birth weight and 8-week gain data. Insufficient data were available to estimate breed effects on growth to ages greater than 8 weeks. Adjustment of 8-week gains for birth weight failed to remove significance ($P \leq 0.01$) of breed effects, but did reduce the magnitude of breed effects. In gain to 8 weeks, the breeds could be grouped into two groups composed of the Ayrshire, Brown Swiss, and Holstein breeds and the Guernsey and Jersey breeds, respectively.

Season of birth had no effect on birth weight or gains to 8 weeks or 6 months of age, but did affect gain from birth to 1 year of age. The specific stress effects of extreme temperature or humidity were not studied. Calves born in the spring gained more to 1 year of age than calves born in winter, summer, or fall. This effect probably resulted from seasonal variations in management practices.

The many rations to which calves included in this study were subjected in the first 8 weeks of life were classified into five broad groups: 1) antibiotic added (aureomycin or terramycin), 2) liberal milk or milk replacement plus hay and concentrate (over 300 lb. milk per 100 lb. birth weight), 3) limited milk or milk replacement plus hay and concentrate (under 300 lb. milk per 100 lb. birth weight), 4) milk or milk replacement only, and 5) filled milk containing unhydrogenated vegetable oil. Growth response to the above rations showed that they could be ranked as listed above with antibiotic-fed calves gaining more weight than any of the other groups. Ration differences established in the first 8 weeks of life tended to persist to 1 year of age. There was some evidence that animals retarded in early life gained more weight between 6 months and 1 year of age than animals fed more liberally in the initial 8 weeks of life.

Correlations of birth weight with gains to various ages all were less than 0.40 indicating that less than 16 per cent of the variation in gain could be attributed to variation in birth weight. The correlation of birth weight with 2-week gain was negative while correlations of birth weight with gain to 4, 6, 8, 12, 16, 26, and 52 weeks of age were positive. The degree of correlation tended to increase to 12 weeks of age and, in most instances, was between 0.30 and 0.40 from 12 weeks to 1 year of age.

Birth weight was correlated ($P \leq 0.05$) with both age at calving and production. Correlation of body weight gain and age at calving were not significant, but both 6-month and 1-year gains were correlated ($P \leq 0.01$) with milk production. Production records were corrected to two times, 305 days, mature equivalent, 3.5 per cent fat

¹Doctoral thesis no. 1607, submitted December 2, 1954. Chairman of Committee, N.L. Jacobson, Department of Animal Husbandry.

²B.S., Texas A and M, College Station, Texas, 1949. M.S., Iowa State College, Ames, Iowa, 1951. Graduate Assistant.

corrected milk. None of the above correlations was large enough to indicate that either birth weight or body weight gain was closely associated with either age at calving or milk production.

SOME ORGANOSILICON COMPOUNDS CONTAINING FUNCTIONAL GROUPS¹

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Department of Chemistry

The preparation of organosilicon compounds containing functional groups was undertaken so that silicon analogs of carbon compounds might be made available for studies in medicine and in agriculture.

Triphenylsilanol (m.p. 150-151°) and acetic anhydride formed 68.5% of easily hydrolyzable triphenylsilyl acetate melting at 93-94°, but no acylation occurred with zinc chloride, aluminum chloride, stannic chloride, or aluminum chloride-sulfuric acid catalyst. Triphenylsilane was not formed by the catalytic reduction of triphenylsilanol, nor by the action of ethanol and sulfuric acid on triphenylchlorosilane. Triphenylsilanol was converted quantitatively into hexaphenyldisiloxane (m.p. 220-222°) when it was refluxed with 98% formic acid.

Triphenylsilane (prepared in 88% yield by the Grignard method in 80% yield by the action of lithium aluminum hydride upon triphenylchlorosilane) melted at 44-45° instead of 36-37° as previously reported (1). Triphenyltin chloride did not react with lithium aluminum hydride. Triphenylstannane was prepared in 42% yield from triphenyltin chloride and sodium in liquid ammonia followed by addition of ammonium bromide.

Triphenylsilane and triphenylstannane reacted with organolithium compounds to give high yields of tetrasubstituted products. Phenyllithium reacted with each hydride to give 90% yields each of tetraphenylsilane (m.p. 230-232°) and tetraphenylstannane (m.p. 228-230°). Methylithium and *n*-butyllithium reacted analogously with triphenylsilane. Phenylmagnesium bromide was without effect upon triphenylsilane in ether, boiling xylene, or ether containing dioxane. Triphenyl-(dimethylamino)-silane (m.p. 80-81°), triphenyl-(diethylamino)-silane (m.p. 84-85°), and triphenyl-(di-*n*-butylamino)-silane (m.p. 60-62°) were prepared in respective yields of 74%, 74%, and 63% when triphenylsilane and lithium salt of the appropriate dialkylamine interacted. The *N*-lithium salts of 2,5-dimethylpyrrole, carbazole, diphenylamine, and methylaniline did not react with triphenylsilane, while lithium hydrazide gave an unstable product.

Triphenyl-(*p*-bromophenyl)-silane (m.p. 167-168°) was prepared in 78% yield by the reaction of triphenylchlorosilane with *p*-bromophenyllithium. Lithium did not react with triphenyl-(*p*-bromophenyl)-silane, and *n*-butyllithium caused the formation of indefinite products after carbonation. A nonacidic substance was formed when lithium *p*-lithiobenzoate and triphenylchlorosilane were caused to interact.

Triphenyl-(*p*-bromophenyl)-silane and lithium dimethylamide gave 50-55% yields of triphenyl-(*m*-dimethylaminophenyl)-silane (isolated as the hydrochloride, m.p. 210-211° dec; m.p. of the picrate 203-204° dec). The free base (from the hydrochloride and 10% sodium hydroxide in 50% ethanol) melted at 95-96°. Triphenyl-(*p*-bromophenyl)-silane did not react with sodium in liquid ammonia.

Trimethyl-(*p*-bromophenyl)-silane, b.p. 53-56° at 0.2 mm, n_D^{20} 1.5285, d_4^{20} 1.2206, and the *p*-chloro compound, b.p. 45-49° at 0.2 mm, n_D^{20} 1.5128, d_4^{20} 1.0285, were prepared in respective yields of 79-89% and 71% by the same method used to synthesize triphenyl-(*p*-bromophenyl)-silane.

Each trimethyl-(*p*-halophenyl)-silane formed *p*-trimethylsilylphenyllithium, the chloro compound doing so sluggishly. The organolithium compound gave *p*-trimethylsilylbenzoic acid (m.p. 111-112°) in yields of 50-72%. The acid reacted with thionyl

¹Doctoral thesis no. 1589, submitted July 27, 1954. Chairman of Committee, Henry Gilman, Department of Chemistry.

²A.B., Fisk University, Nashville, Tennessee, 1936. A.M., Ibid., 1938.

chloride to form p-trimethylsilylbenzoyl chloride, b.p. 74° (0.2 mm), n_D^{20} 1.5309, d_{20}^{20} 1.1023, in 72% yield. p-Trimethylsilylphenyllithium and N-methylformanilide gave a 62% yield of p-trimethylsilylbenzaldehyde, b.p. $69-72^{\circ}$ at 0.2 mm, n_D^{20} 1.5202, d_{20}^{20} 0.9820. The 2,4-dinitrophenylhydrazone melted at $218-220^{\circ}$. Gaseous carbon dioxide reacted with p-trimethylsilylphenyllithium to form a product melting at $110-111^{\circ}$. This substance formed derivatives with hydrozylamine and with 2,4-dinitrophenylhydrazine, but silicon analyses for the original compound and the nitrogen analyses for the derivatives were low (calculations based on the assumption that the original compound was di-p-trimethylsilylphenyl ketone).

Trimethyl-(p-bromophenyl)-silane reacted with lithium dimethylamide to form trimethyl-(m-dimethylaminophenyl)-silane (82% yield), b.p. $73-76^{\circ}$ (1 mm), n_D^{20} 1.5211, d_{20}^{20} 0.9103 (identified by infrared studies). The carbon analog, p-tert-butylbromobenzene, seemingly gave the p-amino derivative.

Triphenyl-(benzyl)-silane, m.p. $97-98^{\circ}$, formed in 85% yield by the interaction of benzyltriethoxysilane and phenyllithium. Triphenyl-(benzyl)-silane was not oxidized by tert-butyl nitrite. Triphenylchlorosilane and benzoyl chloride and magnesium or lithium, and triphenylsilane and benzoyl chloride did not react. Triphenylsilyl cyanide (*in situ*) and phenylmagnesium bromide gave tetraphenylsilane and triphenylsilanol after hydrolysis. No ketonic material was isolated when triphenyl-(phenylethynyl)-silane reacted with mercuric sulfate solution. Ethanolic hydrogen chloride cleaved the silane.

Triphenylchlorosilane and trimethylchlorosilane did not form sulfonium salts with diphenyl sulfide, and triphenylchlorosilane and triethoxychlorosilane did not react with p-acetamidobenzenesulfonamide, N^1 -sodium p-acetamidobenzenesulfonamide, lithium or sodium p-thiocresoxide, or with silver p-toluenesulfinate. Triphenylsilane was not acted upon by lithium p-thiocresoxide.

Triphenylchlorosilane and lithium o- and p-lithiophenoxide gave triphenyl-(o-hydroxyphenyl)-silane (m.p. $229-231^{\circ}$) and the para isomer (m.p. $226-227^{\circ}$) in yields of 61% and 82%, respectively. They did not form phenoxycetic acids nor give color reactions with ferric chloride. Attempts to couple these silicon-containing phenols with p-nitrobenzenediazonium salts resulted in indefinite products from the para compound, while triphenyl-(o-hydroxyphenyl)-silane did not react.

Diphenyldichlorosilane and urea did not react in refluxing ether, diphenylsilanediol (m.p. $158-161^{\circ}$) being formed in 75% yield after hydrolysis. Triphenylchlorosilane, urea, and pyridine in refluxing ether failed to give a silicon derivative of urea. Fusion of urea and triphenylchlorosilane at $190-200^{\circ}$ resulted in the formation of triphenylsilyl isocyanate (67%, m.p. $96-97^{\circ}$). Triphenylchlorosilane and sodium urethan in boiling xylene gave 48% of the isocyanate. Triphenylsilyl isocyanate reacted with phenyllithium to form triphenylsilanol (62%) and benzamide (67%) after hydrolysis. Treatment of the ether suspension with anhydrous hydrogen chloride instead of hydrolyzing it gave triphenylchlorosilane (65%) and benzamide (85%). Triphenylsilyl isothiocyanate (m.p. $98-99^{\circ}$) was formed by the fusion of triphenylchlorosilane and thiourea (68% yield), or by the reaction of the chlorosilane with silver thiocyanate (73%), ammonium thiocyanate (56%), and lead thiocyanate (97%). Triphenylsilyl isothiocyanate and phenyllithium formed tetraphenylsilane (17%), thiobenzamide (37%), and triphenylsilanol (56%) after hydrolysis. With phenylmagnesium bromide, triphenylsilyl isothiocyanate yielded 4.5% hydrogen sulfide and 70% of triphenylsilanol. Triphenylsilyl isothiocyanate and phenylmagnesium bromide, heated after the loss of ether following condenser difficulty, formed 70% of triphenylsilanol and 17% of benzophenone.

Triphenylchlorosilane and p-N, N-dilithiophenyllithium did not form triphenyl-(aminophenyl)-silane. Sodium, p-bromoaniline, and triphenylchlorosilane, after hydrolysis, gave 89% of hexaphenyldisiloxane and 92% recovery of p-bromoaniline. Attempts to nitrate tetraphenylsilane with nitric acid (d. 1.45) resulted in partial cleavage of the silane, or no reaction.

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CHEMICAL AND PHYSICAL PROPERTIES OF VARIOUS FRACTIONS
OF CONNECTIVE TISSUE PROTEINS OF BOVINE MUSCLE¹MADGE MILLER²

Department of Food and Nutrition

Extractions of proteins from bovine skeletal tissue using KCl, NaOH at several concentrations, and at different pH's were studied. Repeated freezing and thawing of beef muscle tissue was used in preliminary attempts to facilitate removal of the intracellular proteins, but was found to be ineffective. The KCl- and NaOH-insoluble proteins were obtained by centrifugation and by entrapment on glass wool. Nitrogen content of the KCl- and NaOH-insoluble residues, before and after autoclaving, and papain digestions were determined by the Nesslerization, tannate precipitation, Kjeldahl, and hydroxyproline procedures. Some residues following KCl, NaOH, and papain treatment were subjected to hyaluronidase digestion.

KCl extracting solutions (Weber-Edsall) were found to remove 80 to 85 per cent of the total nitrogen of muscle tissue when glass wool was used in shake flasks to entrap the connective tissues during the extraction period.

NaOH at concentrations of 0.1 N caused removal of approximately 90 to 95 per cent of beef muscle protein as determined by the Kjeldahl nitrogen procedure.

It was demonstrated that the KCl-insoluble fraction contained a nitrogen-bearing fraction which could not be removed by papain to any appreciable degree, nor could it be removed by water; but it could be solubilized by autoclaving at 15 pounds pressure for 4 hours and by extraction with 0.1 N NaOH for 3 hours at 0.5 to 2.0°C. This fraction did not contain significant amounts of hydroxyproline.

The collagen and elastin content of selected beef muscle tissue, based upon the results of the hydroxyproline assay, were not influenced by prior KCl or NaOH extraction or by papain digestion of the tissue.

Estimates of collagen and elastin content of autoclaved KCl-insoluble muscle tissue based on Kjeldahl nitrogen values are much higher than the collagen or elastin contents determined by the hydroxyproline procedures if 0.1 N NaOH is not used on the residue after the KCl extraction.

Most procedures for analyzing muscle tissue for collagen and elastin which have been described in the literature give results which are suprisingly high when compared with results obtained by hydroxyproline determinations.

The acid hydrolysates of the terminal residues of the KCl-insoluble fractions prepared for hydroxyproline assay exhibited a characteristic color with maximum absorption at 420 millimicrons. Analogous preparations of the terminal residues prepared by the Lowry procedure showed colors and optical density reading which paralleled those of standard solutions containing only hydroxyproline with maximum absorption at 560 millimicrons.

Papain did not digest collagen or elastin from the residues, based upon hydroxyproline data. Absence of hydroxyproline in the enzyme digests demonstrated that papain had not solubilized collagen or elastin fibers *per se* at either acid or alkaline pH's.

Papain was more effective than hyaluronidase in releasing reducing substances from KCl- and NaOH-insoluble muscle tissue residues. Prior treatment of the residues with papain enhanced the activity of the hyaluronidase on the residues. Some ground substance remained after treatment of the residues with 0.6 M KCl, 0.1 N NaOH, or papain.

Results of these investigations indicate quantitative accounting of the nitrogen in bovine skeletal tissue may be effected by acceptance of the following fractions: a KCl-soluble portion, approximating 80 to 85 per cent; a collagen and elastin fibrillar fraction of 5 to 6 per cent; an alkali-labile, autoclave-labile moiety of 8 to 12 per cent. The insignificant amounts of hydroxyproline in the latter preclude its classification as collagen or elastin. It is suggested that this fraction is a component of the ground substance.

¹Doctoral thesis no. 1582, submitted July 15, 1954. Chairman of Committee, Belle Lowe, Department of Food and Nutrition.

²B.S., Iowa State College, Ames, Iowa, 1939. M.S., *Ibid.*, 1941. Assistant Professor.

STUDIES ON THE STRUCTURE AND CATALYTIC PROPERTIES OF VITAMIN B₁₂¹RICHARD A. MURIE²

Department of Chemistry

The isolation of vitamin B₁₂ was achieved in 1948 and was the culmination of years of effort on the part of many workers. Much effort has been devoted to the study of the physical and chemical properties of vitamin B₁₂. The complete proof of the structure of vitamin B₁₂ and finally the production of the vitamin by synthesis is the ultimate goal of the research worker.

The work undertaken in this thesis represents one more building block which may be added to the slowly growing fund of information on the physical and chemical properties of vitamin B₁₂.

The effects of heating vitamin B₁₂ in a stream of dry nitrogen at various temperatures were studied. Vitamin B₁₂ was heated successively at temperatures from 109° to 243°. At temperatures of 180° or more a rapid loss in weight occurred. This was due to the liberation of ammonia from amide groups with the subsequent formation of an imide group as was shown by the formation of a new band in the infrared at 5.7 μ .

The product remaining after heating the vitamin to 210° was a black material which dissolved in water to yield a brown-orange solution. It formed a purple colored dicyanide complex when treated with excess sodium cyanide. The spectra of vitamin B₁₂ dicyanide formed with the 210° product were similar in the ultraviolet region. However, the dicyanide complex of the 210° product did not show the pronounced peaks in the visible at 537 m μ and 576 m μ that are present in vitamin B₁₂ dicyanide.

When vitamin B₁₂ was heated to 243° two molecules of ammonia were liberated and extensive damage was done to the molecule. The loss in weight was more than that due to the release of the ammonia alone. The black residue did not dissolve in water, benzene, methanol, dioxane, acetone, carbon disulfide, or chloroform. It was somewhat soluble in a sodium cyanide solution. The absorption spectra of the cyanide adduct did not show peaks in the visible region at 527 m μ and 576 m μ . The strong maximum in the ultraviolet at 366 m μ was reduced to a mere hump, the maximum of which occurred at 355 m μ .

The action of various phosphatases on vitamin B₁₂ was studied. The phosphatase employed were prostate phosphatase, polydase, and purified diesterase from rattlesnake venom. None of these hydrolyzed the phosphate linkage in vitamin B₁₂.

Crystalline vitamin B₁₂ was treated with concentrated hydrochloric acid for 2 hours at room temperature and then neutralized and treated with polydase enzyme. This treatment caused the hydrolysis of greater than 80 per cent of the phosphate in the molecule.

The free phosphate produced by hydrolysis was determined by the formation of molybdophosphate blue complex. In solutions containing vitamin B₁₂ it was necessary to extract the vitamin B₁₂ before addition of the acid molybdate solution; otherwise a pink flocculent precipitate formed upon the addition of acid molybdate. The vitamin B₁₂ was removed by extraction as the dicyanide complex into benzyl alcohol.

About 280 mg of vitamin B₁₂ was subjected to a three-stage hydrolysis. It was treated with concentrated hydrochloric acid for 2 hours at room temperature, neutralized, incubated with polydase enzyme at 37° for 4 days, and finally heated to 98° in 6N hydrochloric acid for 30 hours. The hydrolysate was put through 40 transfers in a Craig countercurrent distribution apparatus employing 1 N hydrochloric acid equilibrated with *n*-butanol as the stationary phase and *n*-butanol equilibrated with 1 N hydrochloric acid as the moving phase.

The red acid fragment moved rapidly and was concentrated in tube 40. A nitrogen analysis of the contents of each tube showed that three distinct separations were achieved. The ammonia and 1-amino-2-propanol fragments were found in tubes 0 through 7. The benzimidazole was found in tubes 18 through 28 and the red acid fragment in tubes 31 through 40.

The ratio of nitrogen to cobalt in tubes 30 through 40 was found to be 3.91, which is in quite good agreement with the theoretical value of 4.0.

¹Doctoral thesis no. 1666, submitted June 1, 1955. Chairman of Committee, Harvey Diehl, Department of Chemistry.

²B.S., Ohio University, Athens, Ohio, 1950. M.S., Iowa State College, Ames, Iowa, 1952. Graduate Assistant, Department of Chemistry and Industrial Science Research Institute.

A clean separation of the free ammonia and the 1-amino-2-propanol was not obtained and the results were not conclusive enough to settle the controversy as to the number of molecules of 1-amino-2-propanol present in vitamin B₁₂.

The cobalt analysis showed that about 3.5 per cent of the cobalt was stripped from the molecule. The major portion of the cobalt was found in tubes 38 through 40.

Hydrolysis of the phosphate linkages was not clean. The greatest amount of phosphate appeared in the tube zero, possibly as free phosphoric acid. The second band appeared in tube 3 and may be present in combination with 1-amino-2-propanol. The third band appeared in tube 21, where the benzimidazole also peaks, and is undoubtedly attached to the benzimidazole moiety through the ribose group. The fourth band occurred in tube 32 and probably attached to some unidentified fragment.

Vitamin B_{12a} was studied as a substitute for pyridoxal in the oxidative deamination of glycine at pH 4 and pH 9.6. No catalytic activity was observed and deamination did not proceed.

The catalytic reduction of cyanide to methylamine was studied. No methylamine was produced by bubbling hydrogen through a cyanide solution containing platinum oxide as a catalyst. The addition of vitamin B_{12a} and vitamin B_{12r} did not promote the reduction for no methylamine was found.

DISSEMINATION STUDIES AND CHEMICAL CONTROL OF OAK WILT¹

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Department of Botany and Plant Pathology

Methods of long range dissemination of the oak wilt pathogen, *Endoconidiophora fagacearum* Bretz, and control of the disease are two of the main problems confronting investigators in this field. Birds, rodents, and insects have been suggested as possible vectors of the pathogen. In forested areas some success has been achieved in controlling the disease by eradication and sanitation. Chemotherapy has shown promise for controlling oak wilt in individual trees having high aesthetic value.

Birds, especially woodpeckers, were studied as possible vectors of the oak wilt fungus. They were attracted to oak wilt areas with feeding stations, where they were trapped, banded, tested for fungi, and released. After discovery of fungous mats and pads, automatic traps were placed on trees producing such structures. During this time a few birds were shot on diseased trees and taken to the laboratory for more thorough investigation. Downy and hairy woodpeckers were the most numerous species encountered in the total of 332 birds trapped, shot, and tested. The oak wilt fungus was not recovered from any of the birds.

During the season of 1952 and 1953, various experiments were conducted to test the effectiveness of different chemicals for killing red oak trees, using four methods of application. These were chemical applications for the basal portion of the trees, to frills in the bark, to holes in the basal portions, and to the soil around the trees. Chemicals were applied during dormant, bud-break, full-leaf, and senescent-leaf periods.

Ten per cent propylene glycol butyl ether ester of 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) in fuel oil applied as a basal spray to frilled, dormant, red oak trees gave the quickest and most complete top kill. For spring treatments (bud-break and full-leaf) 10 per cent 2,4,5-T ester applied as a basal spray to either frilled or unfrilled trees killed the tops quickly and completely. Basal sprays applied to unfrilled trees during the full-leaf and senescent-leaf periods produced little injury. Ammonium sulfamate (Ammate) applied to frills was slightly less effective than basal sprays of 10 per cent 2,4,5-T applied to frilled trees during dormant and bud-break periods. Results from applying Ammate and sodium arsenite to holes in the bases of trees during these periods varied from poor to fair kill. Sodium arsenite applied to frills during the full-leaf period gave quick and complete kill of tops.

¹Doctoral thesis no. 1608, submitted December 2, 1954. Chairman of Committee, W.H. Bragonier, Department of Botany and Plant Pathology.

²B.S., University of New Hampshire, Durham, N.H., 1949. M.S., Ibid., 1952. Graduate Assistant, Agricultural Experiment Station.

When applied to incomplete frills on trunks of red oak trees the liquid concentrate of the amine salt of 2,4-dichlorophenoxyacetic acid (2,4-D Amine) produced excellent kill as contrasted to the poor kill from concentrated 2,4,5-T applied in the same manner. Soil applications of 3-(p-chlorophenyl)-1, 1-dimethylurea (C.M.U.) and sodium trichloroacetate (sodium T. C. A.) plus sodium chlorate (Atlacide) were the least effective chemicals used for the crown kill of red oak trees.

Roots were killed two to three feet from the root collar on trees treated with basal sprays of 10 per cent 2,4,5-T applied to frills during dormant, bud-break, and full-leaf periods. Basal sprays of 10 per cent 2,4,5-T applied to unfrilled trees exhibited the same amount of kill on trees treated during dormancy and bud-break. Root kill was lacking on all trees treated with Ammate. Trees treated with sodium arsenite in frills during the full-leaf period showed the best root kill of all. Applications of concentrated 2,4-D Amine in frills gave the most root kill for spring treatments.

Control of oak wilt infections by the introduction of chemicals in the root zones or on the foliage of trees was attempted. Prophylactic treatments were more successful than therapeutic ones when chemicals were applied to the root zones of large trees with a soil injection needle. Of the chemicals applied in this manner alkyldimethyl-ethylbenzylammonium chloride (B.T.C.-471) and sodium 2-mercaptobenzothiazol + sodium dimethyldithiocarbamate (Vancide-51) exhibited the most promise when applied before inoculation.

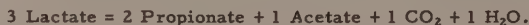
Statistical analysis of the results from an experiment with 1800 five-year-old pin oak trees in which five chemicals at three rates were injected into the root zones at three times revealed no significant differences between chemicals, rates, and times of application. Two techniques used to gather evidence on the effectiveness of the treatments, 1) estimating percentage of top remaining healthy after treatment, and 2) measuring tree diameters at the beginning of the growing season (before treatment) and in the fall at the end of the experiment, produced usable evidence which was in close agreement. By analyzing statistically the growth increment data from time 2 (treated, noninoculated checks) significant linear and quadratic effects were discovered. The highly significant linear effects indicated increase of phytotoxicity with rate. That this increase was less at the lower rates was indicated by the significant quadratic effects. Use of the growth increment data in this statistical analysis led to the discovery of phytotoxic effects not suspected and not revealed by estimating percentage of top remaining healthy after treatment.

From a total of eleven chemicals, Malachite green, Mercurine "100", and Mercupron showed promise as therapeutants when applied to the foliage of six-year-old trees. Adjuvants did not increase the effectiveness of the chemicals.

METABOLISM OF THE PROPIONIC ACID BACTERIA¹

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Department of Bacteriology

The metabolic activity of the propionic acid bacteria is dependent upon the conditions of growth such as age of cells, pH of the culture medium, and the nature of the carbohydrate carbon source. Propionibacterium pentosaceum grown in glucose medium possesses an active succinic decarboxylase which functions optimally at pH 5.2. Cells grown in lactate medium exhibit low levels of or no activity of succinic decarboxylase yet utilize lactate under anaerobic conditions with the formation of the usual products of the propionic acid fermentation. The reaction may be represented by the equation:



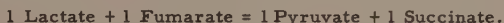
Formation of propionate occurs by a sequence of reactions other than that involving decarboxylation of succinate.

¹Doctoral thesis no. 1677, submitted June 4, 1955. Chairman of Committee, C.H. Werkman, Department of Bacteriology.

²B.S., College of the City of New York, 1943. Instructor.

Under anaerobic conditions, formation of carbon dioxide with lactate as substrate is preceded by a lag period. With pyruvate as substrate, formation of carbon dioxide occurs almost instantaneously. Under aerobic conditions, uptake of oxygen with lactate as substrate occurs instantaneously. With pyruvate as substrate, uptake of oxygen is preceded by a lag period. Under anaerobic conditions with lactate as substrate, methylene blue is reduced prior to formation of carbon dioxide. With pyruvate as substrate, formation of carbon dioxide precedes reduction of methylene blue.

The pH optimum for reduction of methylene blue by whole cells with lactate as substrate is 6.4. The pH optimum for reduction of methylene blue by cell-free extracts with lactate as substrate is 7.4. Lactic dehydrogenase is inhibited only slightly by dialysis. Using cell-free extracts, fumarate and oxalacetate function as acceptors of hydrogen derived from lactate. At pH 7.4, the following reaction occurs:

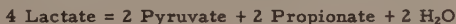


At lower pH levels, the reaction is no longer that represented by the above equation. Maximum utilization of lactate and formation of pyruvate occur at pH 5.6. The amount of lactate utilized is approximately twice the amount of pyruvate formed. The cell-free extract cannot utilize pyruvate, lactate, and succinate per se. Analysis of the reaction mixture indicated formation of an amount of propionate equivalent to that of pyruvate formed. The reaction may be represented by the equation:



Fumarate is required, but only in small amounts. Adenosine diphosphate stimulates the reaction.

On the basis of these findings and proposed mechanisms for the utilization of pyruvate, the utilization of lactate may be represented as follows:



DIRECT PREPARATION OF ORGANOLITHIUM COMPOUNDS FROM LITHIUM AND RX COMPOUNDS¹

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The direct reaction of lithium with the corresponding halides, halogen-metal interconversion, and metalation are the three types of reactions most frequently used in the preparation of organolithium compounds. It was the purpose of this thesis to re-investigate the factors influencing yields afforded by the direct method. Many reagents of purity and of special form not available to earlier workers (1,2) have also been utilized.

The use of a temperature of -20° to -30° during the addition of the *n*-butyl bromide-ether solution to lithium in diethyl ether consistently afforded 85-93 per cent yield of *n*-butyllithium as determined by double titration (3). When *tert*-butyllithium was prepared from *tert*-butyl chloride and lithium foil in pentane, a 57 per cent yield by a simple acid titration and a 46.8 per cent yield by double titration was obtained. The yields of *n*-dodecylithium from *n*-dodecyl chloride and lithium ribbon in petroleum ether (b.p. 28-38°), pentane and heptane, respectively, were 61, 58.5, and 4.10 per

¹Doctoral thesis no. 1645, submitted March 14, 1955. Chairman of Committee, Henry Gilman, Department of Chemistry.

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cent by double titration. However, by a simple acid titration, the yields, in the same order, were 104, 107, and 91 per cent. These results indicated that the simple acid titration method was inadequate for determining the concentration of long-chained alkyl lithium compounds prepared in these solvents. The decrease in the titer of *n*-dodecyl lithium in heptane, after standing for 3 days at room temperature, showed that long-chained alkyl lithium compounds are somewhat unstable, even in an inert solvent. When the heptane mixture was allowed to settle, the yield of *n*-dodecyl lithium in the supernatant liquid was slightly lower than that in the suspension both by double and by simple acid titration. This meant that some inorganic base was present in the heptane solution and some of the *n*-dodecyl lithium was not in solution. The yield of *n*-octadecyl lithium from *n*-octadecyl bromide in diethyl ether at 0° was 63 per cent by double titration; at 10°, it was 36.5 per cent. When the preparation was carried out in refluxing heptane, the yield of *n*-octadecyl lithium from *n*-octadecyl chloride was 4.17 per cent by double titration.

1,10-Dilithiodecane was prepared from 1,10-dibromodecane and lithium ribbon in diethyl ether in a 70.6 per cent yield (double titration) and a 42.5 per cent yield by carbonating to 1,10-decanedicarboxylic acid. However, when attempts to prepare 1,3-dilithiopropane and 1,2-dilithioethane from the corresponding chlorides and lithium dispersion were carried out in diethyl ether and in ethylene glycol dimethyl ether, the only evidence for the presence of organolithium compound was the positive Color Test I (4). Lithium dispersion has not previously been used in the preparation of organolithium compounds from the corresponding halides.

Aryllithium compounds were prepared in excellent yields from the corresponding bromides by adding the aryl bromide-ether solution to lithium in diethyl ether at a rate sufficient to maintain a gentle reflux without external heating or cooling. The following aryllithium compounds were prepared (the percentages refer to the yields by a simple acid titration): phenyllithium (100 per cent), 2-biphenyllithium (98.5 per cent), *m*-tolyllithium (94.5 per cent), mesityllithium (100 per cent) and 2-naphthyllithium (100 per cent). Aryl chlorides afforded good yields of the corresponding aryllithium compounds when a gentle reflux was maintained by external heating during the addition of the aryl chloride-ether solution. The compounds prepared were phenyllithium (92.5 per cent) and *m*-tolyllithium (71.3 per cent). *p*-Triphenylsilylphenyllithium was prepared in a 70 per cent yield from *p*-triphenylsilylbromobenzene by using a similar procedure. The reaction of fluorobenzene in diethyl ether with lithium ribbon and lithium dispersion, respectively, gave phenyllithium in yields of 0.72 and 0.51 per cent as determined by carbonation to benzoic acid. In the experiment carried out with lithium ribbon, an 18.4 per cent yield of biphenyl was also isolated. When a mixture of fluorobenzene, lithium ribbon, and triphenylchlorosilane was refluxed in ethylene glycol dimethyl ether, a 16.5 per cent yield of tetraphenylsilane was obtained.

2-Biphenylboronic acid and 4-dibenzofuranboronic acid were prepared from the reaction of the corresponding aryllithium compounds and tri-*n*-butylborate at -70°. The reported melting point of 2-biphenylboronic acid is 126° and that of 2-biphenylboronic acid anhydride is 196-197° (5). However, their infrared spectra and neutral equivalent values indicate that the compound reported as the acid is a hydrated acid while the higher melting form is the anhydrous acid. The melting point of 4-dibenzofuranboronic acid could not be accurately determined because of its tendency to undergo dehydration to the anhydride form. Pure 4-dibenzofuranboronic acid anhydride, prepared by recrystallizing the acid from benzene, melted at 288-289°. From an attempt to prepare mesityleneboronic acid from the reaction of mesityllithium and tri-*n*-butyl borate at 0°, a nonacidic material (m.p. 145-146°), tentatively called dimesityleneboronic acid, was obtained.

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ETHNIC ATTITUDES OF CHILDREN IN
SELECTED TOWN AND RURAL AREAS IN IOWA¹

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In this study an analysis is made of three aspects of the opinions of white, Gentile, and chiefly non-Catholic pupils in the public schools of eight small towns in an Iowa county. In the fall of 1951 all pupils (except for a few absentees) in the sixth, ninth, and twelfth grades of these schools were given questionnaires in their classrooms. The questionnaires included thirty opinion statements, six each of these statements referring to Negroes, to Mexicans, to Catholics, to Jews, and to such inclusive social categories as "other races and religions." (These statements expressed willingness to associate with the designated groups in certain situations, to grant that members of a group had certain "rights," to grant that a given group behaved much like "all other people," or to grant that a given group had certain admirable characteristics. For each statement, respondents were asked to select one of three responses, namely, "I disagree," "I cannot quite agree," or "I agree completely.") In addition, respondents were asked for certain information about: 1) their social characteristics such as sex, grade in school, youth organization memberships, church affiliations, and frequencies of church attendance; 2) their parents' social characteristics such as amount of schooling, place of residence, kinds of foreign languages spoken, church affiliations, and occupations of fathers; 3) their choice of best liked and least liked classmates. Four hundred twenty-four questionnaires were secured, two of which were excluded from the analysis for incompleteness and inconsistency and 25 of which were analyzed separately since these respondents indicated that they were Catholics.

The groups, i. e., Negroes, Mexicans, etc., named in the opinion statements are termed ethnic groups chiefly because there seem to be widely shared attitudes in various parts of the United States that inter-marriage between members of these groups and outsiders is undesirable and viewed with disapproval. They are termed minorities because the writer concluded that there was evidence that many Americans in majority ethnic groups feel that these groups' distinguishing features are not objects of emulation and that many of these same persons approve of the denial of certain social privileges to these groups on the basis of group membership--privileges which are granted by other criteria to nonmembers of these minorities.

Two objectives guide the formulation of the problem and analysis: 1) what are the clusters of correlation among the responses to the opinion statements? Do these young people as individuals tend to respond uniformly in agreeing or disagreeing with the statements on the basis of the minority group names; on the basis of the type of association or "right" designated, or on the basis of whether they were asked about preferences in personal association or willingness to grant "rights" or to "think well" of these groups? 2) How are differences in the social characteristics of the respondents and their parents and the popularity of respondents among their classmates associated with differences in the respondents ethnic attitude scores, each score being a weighted estimate of the extent to which a given respondent agreed or disagreed with all of the statements or with sub-groups of statements, responses to which were highly correlated among all respondents.

Evidence related to the first objective was organized by estimating the correlation between responses to each pair of the thirty statements for the 397 non-Catholic respondents (1). From a 30 by 30 matrix of these correlations, a first factor interpreted as generalized "tolerance" was derived and weighted scores estimating differences in generalized "tolerance" computed (2). Clusters were discovered through a technique termed correlation profile analysis (3).

Evidence related to the second objective was organized chiefly through the use of a technique termed covariance analysis which combines analysis of variance and multiple linear regression techniques, the attitude or opinion scores being the dependent variables with various combinations of social and popularity characteristics as independent variables (4).

Since respondents were not selected with known probabilities from a larger uni-

¹Doctoral thesis no. 1587, submitted July 17, 1954. Chairman of Committee, Joseph B. Gittler, Department of Economics and Sociology.

²B.A., State University of Iowa, Iowa City, 1939. M.S., Iowa State College, Ames, 1948.

verse, results of the analyses may not be used as a basis for statistical inference about young people in Iowa or in any more inclusive universe. However, comparisons were made with results of studies which were comparable in specific respects and which were done in the Midwest, New England, and on a nation-wide sample of adults. It is believed that some of the results are quite similar and that noticeable differences could be explained in terms of sociopsychological theories.

As a result of the first factor and correlation analyses it was found that:

- 1) There is a clustering of responses to statements about personal association with Negroes which is distinct from responses to granting "rights" to Negroes and from responses to all other specified minority groups.
- 2) There is a clustering of responses to all statements about Catholics which is distinct from responses to any other minority, a clustering, however, which is more expressive of apprehensions about Catholic "power" than of aversions to personal association with Catholics. Apart from variations in generalized "tolerance," apparently many young people who are apprehensive about Catholic "power" are "tolerant" toward personal association with Negroes and vice versa.
- 3) A less distinct clustering of responses to statements about personal association with Jews and statements about those "rights" of Negroes, Mexicans, and Jews which imply personal association is highly correlated with generalized "tolerance."
- 4) Differences in distributions of responses to each of the thirty statements indicate that most aversion is expressed to: a) relations with Catholics which imply the exercise of controlling "power" by Catholics; b) personal association with Negroes; c) those associations with Mexicans and with "all races" which seem to imply "romance." (The only two statements which designated situations implying "romance" referred to dancing with "Mexicans" and the "right" of "all races" to patronize dance halls.)

As a result of the covariance analysis and descriptive comparisons of attitude, score means and variances for various sub-groups of respondents, two main conclusions were tentatively suggested.

- 1) In general, in this county the child who lives in a community with a single predominant ethnic group identified operationally as a church group of similar nationality, and who is a member of this group is less "tolerant" than a child who lives in an ethnically heterogeneous community.
- 2) In general, a child who belongs to a Protestant denomination with a very short historical record or no record of formal cooperation in the main interdenominational agencies of American Protestantism is less "tolerant" than a child in a denomination with a longer historical record of such cooperation.

Other findings were:

- 1) In general, pupils who are most popular with their classmates are more "tolerant" than the less popular, but pupils who conform most carefully in "liking" their popular classmates and "disliking" their unpopular classmates are less "tolerant" than those who do not so conform.
- 2) On the average, girls in upper school grades are more "tolerant" than girls in lower grades, but boys, irrespective of grade, are similar in "tolerance" to lower grade girls.

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3. See: Tryon, *op. cit.*, pp. 4-17; 41-76.
4. For techniques see: Snedecor, George W. Statistical Methods. Fourth ed. Ames, Iowa, Iowa State College Press. pp. 218-227. 1946.

STRESSES DEVELOPED BY IMPACT IN A BEAM¹RICHARD T. OTHMER²

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The solutions for the stresses developed in a beam due to the sudden application of a disturbance were approached through the equations of motion of a differential element of the beam. It was assumed that the beam was composed of a homogeneous isotropic material, that the stress-strain relationships satisfied Hooke's law, and that a plane stress condition existed.

The partial differential equations of motion were expressed in terms of the displacements by the use of the stress-strain and strain-displacement relationships. Displacement functions were defined to obtain two equations, each with only one unknown function. The two equations arrived at were wave equations. The stresses and displacements were expressed in terms of these functions.

Various methods of disturbing the boundaries of a finite rectangular beam were considered. Expressions for stresses and displacements in the form of infinite series were obtained for the conditions of suddenly applied end moments and shears, and for the case of a suddenly applied force at midspan. An indication was also given of the form of the solution obtained with use of the Fourier and Laplace transformations for the case of the impact load at midspan. The different stress and displacement expressions were discussed and a need for a numerical expression for the impact disturbances was indicated.

An experimental setup was described to determine the strains (and hence stresses) produced in a simply supported beam when it was subjected to an impact load applied at midspan. SR-4 strain gages were used in a simple potentiometer circuit and the change in voltage due to a change in strain in the member was amplified and then obtained from the screen of a cathode-ray oscilloscope.

An attempt was made to obtain the strains developed in a steel beam approximately 4" x 4" in cross section and with a span of 20" when it was subjected to an impact load at midspan. No results were obtained even though the recording gages were located about 1/4" below the surface of the beam receiving the impact and the impact was sufficiently great to cause plastic deformation on the surface of the beam. A rubber beam of approximately the same dimensions was substituted for the steel beam. Definite signals were produced by the strain gages on the rubber beam. The damping and dispersion of the strain wave as it progressed through the beam were very evident and it was concluded that a material with a modulus of elasticity somewhere between that of steel and of rubber should be used. The velocity of propagation of a compressive strain wave was obtained and an indication of at least two types of waves to exist along the upper surface of the beam following the application of the impact load.

¹Doctoral thesis no. 1576, submitted July 12, 1954. Chairman of Committee, Glenn Murphy, Department of Theoretical and Applied Mechanics.

²B.S., South Dakota State College, Brookings, S.D., 1938. M.S., Iowa State College, Ames, 1947. Assistant Professor, Theoretical and Applied Mechanics, and Associate Engineer, Institute for Atomic Research.

EFFECT OF EPINEPHRINE, CORTISONE ACETATE, AND ADRENOCORTICOTROPIN
ON CIRCULATING EOSINOPHILS, PLATELETS, AND MARROW MEGAKARYOCYTES
OF INTACT AND SPLENECTOMIZED ALBINO RATS¹

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The experiments in this investigation were undertaken to determine the effect of injected epinephrine, ACTH, and cortisone acetate upon blood platelet, eosinophil, and marrow megakaryocyte values of the intact and splenectomized white rat. One hundred fifty-eight, two- and three-month old rats of the Holtzmann-Rolfsmeyer strain were used. Counting and surgical procedures were perfected, and the following experiments were carried out.

A preliminary study of the effect of handling, anesthetizing, and injecting 1 ml of of physiological saline, intraperitoneally, upon the platelet and eosinophil values of the intact and splenectomized rat led to the following results and conclusions:

1. Blood platelet counts of both intact and splenectomized rats, taken at the 0-hour, fifteen minute, thirty minute, sixty minute, two hour, and four hour periods, showed no significant changes throughout the period of observation.

2. Eosinophil counts of intact and splenectomized rats showed no significant change until the two hour period, at which time they dropped sharply.

3. It is to be concluded that blood platelets were unaffected by this mild form of stress, whereas the eosinophils were sensitive enough to respond, finally at the two hour period of the experiment.

A study of the effect of intraperitoneal injections of 0.25 ml of epinephrine (1:10,000) per 100 grams of body weight, on blood platelet, eosinophil and marrow megakaryocyte values of the intact, sham-splenectomized and splenectomized white rat led to the following results and conclusions:

1. Platelet means of the intact group showed a 65 per cent increase at the fifteen minute period and a 43 per cent increase at the thirty minute period; the sham-splenectomized group showed a 69 per cent and a 66 per cent increase in platelet means over the same period of time. From these data it was concluded that both intact and sham-splenectomized rats would respond significantly to epinephrine but that there was no significant difference between groups. On the basis of this fact shams were not run in subsequent experiments.

2. The mean platelet increase of the splenectomized rats was not significant; only 21 and 24 per cent increases showed at the fifteen and thirty minute periods, respectively.

3. Epinephrine action upon platelet values was immediate and of short duration upon all three experimental groups.

4. All three experimental groups showed significant decreases in eosinophil values at the thirty and sixty minute periods.

5. The splenectomized group showed a significant megakaryocyte increase under epinephrine treatment.

6. A ± 20 per cent change equilibrates with a standard deviation of 68,000 on forty normal, untreated rats and therefore affirms the significance of the platelet increases as seen in the intact and sham-splenectomized groups under epinephrine treatment.

A short-term study of the effect of a single dose of two units of ACTH, per 100 gm of body weight, upon platelet, eosinophil, and megakaryocyte values of the splenectomized and intact rat led to the following results and conclusions:

1. The initial effect was one of immediate, significant platelet depression; release from this depression was noted at the tenth hour of the experiment.

2. Both groups were under the same degree of adrenocortical stress as was affirmed by their eosinopenic condition from the third hour to the end of the period of observation.

3. Megakaryocytes increased significantly for both groups under ACTH treatment.

A long-term twenty-day study of the effect of two units of ACTH daily, per 100 gm of body weight, upon platelet, eosinophil, and megakaryocyte values of the splenectomized and intact rat led to the following results and conclusions:

¹Doctoral thesis no. 1583, submitted July 15, 1954. Chairman of Committee, Oscar E. Tauber, Department of Zoology and Entomology.

²B.A., Dakota Wesleyan University, Mitchell, S. Dak. 1942, M.S., Iowa State College, Ames, 1951. Instructor.

1. The first day's data of this long-term experiment were consistent with the results of the ACTH short-term experiment.

2. The intact group showed a significant increase in platelet values, reaching a top of 134 per cent increase on the eleventh day of the experiment. The splenectomized rats responded to a lesser degree with a 52 per cent increase on the ninth day.

3. ACTH was very effective in bringing about thrombocytosis in the intact animal; less so in the splenectomized rat.

4. Both groups were in eosinopenia through the fourteenth day of the experiment. Megakaryocyte data supported the platelet value increases in this experiment.

A short-term study of the effect of a single dose of 2.5 mg of cortisone acetate, per 100 gm of body weight, upon platelet, eosinophil, and megakaryocyte values of the splenectomized and intact rat led to the following results and conclusions:

1. The early effect of this corticoid upon the platelet values of both groups was one of depression. Depression was short-lived; however, the values returned to 0-hour levels at the two hour period.

2. Both groups were in complete eosinopenia at the fourth hour of observation.

A long-term twenty-day study of the effect of 2.5 mg of cortisone acetate daily, per 100 gm of body weight, upon platelet, eosinophil, and megakaryocyte values of the splenectomized and intact rat led to the following results and conclusions:

1. The platelet means of both groups rose steadily from the first through the fourth day of the experiment.

2. The intact group showed a 131 per cent platelet increase on the fourth day and a 148 per cent increase on the sixth day. The platelet values of the splenectomized group never rose above the top 70 per cent increase that was established on the fourth day.

3. This experiment again demonstrated that the intact animal responded more significantly to hormonal induced stress than did the splenectomized animal.

4. Both groups were in eosinopenia on the fifth day, and never recovered during the period of the experiment.

In general, the above experiment indicates that splenectomy does not protect the white rat from pituitary-adrenal response; this was affirmed by the eosinopenic condition of the splenectomized group in both the ACTH and cortisone experiments.

Furthermore, from the data of this investigation it is concluded that eosinopenia is not due to sequestration of eosinophils by the spleen. Eosinopenia resulting from adrenocortical stress was as evident in the splenectomized as in the intact rats.

In addition, sudden significant changes in platelet values, of animals under stress, can no longer be charged to a function of the spleen; rapid shifts in platelet numbers were as evident in splenectomized as in intact rats. It should be noted, however, that the degree of response was less in the splenectomized than in the intact animal.

KINETICS OF THE EXCHANGE REACTION BETWEEN TWO OXIDATION STATES OF CERIUM¹

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The radioactive cerium exchange reaction was employed to study the electron transfer reaction in perchloric acid between cerium(III) and cerium(IV). In particular, the study was carried out to extend previous investigations, to elucidate further, if possible, the nature of the ionic species of cerium that exist in perchloric acid solution, and to examine the various factors determining the rate of exchange.

In approximately six formal perchloric acid, the dependence of the exchange rate with respect to cerium(III) has been reported to be first order, the dependence with respect to cerium(IV) an order between zero and one, and reciprocal first order dependency with respect to the hydrogen ion concentration. It has also been observed that both fluoride and chloride catalyze the exchange reaction.

¹Doctoral thesis no. 1644, submitted March 12, 1955. Chairman of Committee, Frederick R. Duke, Department of Chemistry.

²B.S., Iowa State College, Ames, Iowa, 1949. M.S., *Ibid.*, 1951.
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Separation of the reactants was accomplished by using tri-*n*-butyl phosphate to extract cerium(IV) from nitric acid solution. After reduction by hydrogen peroxide the cerium(IV) was quantitatively recovered from tri-*n*-butyl phosphate by re-extraction with water. It was found that only a small amount, if any, cerium(III) was extracted by tri-*n*-butyl phosphate and that the separation and recovery of cerium(IV) was essentially complete.

The dependence of the exchange rate in six formal perchloric acid with respect to cerium(III) was studied by the usual kinetic technique of independently varying the concentration of the reactant under study, in this case cerium(III). A first order dependency of the exchange rate was found with respect to cerium(III).

It was found that the concentrations of both cerium(III) and cerium(IV) had to be determined in each experiment, due to the presence of cerium(III) in cerium(IV) perchlorate solution. The dependence of the exchange rate with respect to cerium(IV) could not be determined by the usual kinetic procedure because it was not possible to independently vary the cerium(IV) concentration. Since first order dependency of the exchange rate was determined with respect to cerium(III), the over-all exchange rate can be expressed as:

$$R = k [\text{Ce(III)}] f [\text{Ce(IV)}] \quad (1)$$

Hence, $f [\text{Ce(IV)}]$ can be determined from a plot of $R / [\text{Ce(III)}]$ against $[\text{Ce(IV)}]$. It was found from such a plot that exchange did not occur via any path independent of the cerium(IV) concentration, but that both first order and higher order dependencies existed with respect to cerium(IV). When $R / [\text{Ce(III)}] [\text{Ce(IV)}]$ was plotted against $[\text{Ce(IV)}]$ a straight line was obtained indicating the higher order dependency to be second order with respect to cerium(IV). On the basis of this, the rate expression must be of the form:

$$R = k' [\text{Ce(III)}] [\text{Ce(IV)}] + k'' [\text{Ce(III)}] [\text{Ce(IV)}]^2 \quad (2)$$

Two independent procedures were employed in studying the dependence of the exchange rate with respect to the hydrogen ion concentration. In one procedure the exchange rates were determined in two series of experiments in which the hydrogen ion concentrations were 5.04 and 5.85 formal, respectively, and the cerium(III) and cerium(IV) concentrations were varied in each experiment. The results obtained were interpreted in terms of hydrolyzed species of cerium(IV).

The over-all exchange rate was explained on the basis of one exchange reaction between hydrolyzed monomer, Ce(OH)_3^+ , and cerium(III) and a second exchange reaction between hydrolyzed dimer, HOCeOce^{+5} , and cerium(III). Consistent with this, the expression for the over-all rate of exchange must be of the following form:

$$R = k' [\text{Ce(III)}] [\text{Ce(OH)}_3^+] + k'' [\text{Ce(III)}] [\text{HOceOce}^{+5}] \quad (3)$$

Equation 3 may be expressed in terms of the total cerium(IV) concentration, $T_{\text{Ce(IV)}}$, which was assumed to be equal to the sum of Ce(IV) and CeOH^{+3} concentrations, and appropriate equilibrium constants.

$$R = \frac{k_4 K_1 K_2 K_3 [\text{Ce(III)}] T_{\text{Ce(IV)}}}{[\text{H}^+]^2 [\text{H}^+ + K_1]} + \frac{k_6 K_1^2 K_5 [\text{Ce(III)}] T_{\text{Ce(IV)}}^2}{[\text{H}^+] [\text{H}^+ + K_1]^2} \quad (4)$$

Equation 4 is of the same form as equation 2 which was found to be necessary from the studies of the cerium(III) and cerium(IV) dependencies.

The exchange rates were determined in series of experiments in which the hydrogen ion concentration was varied from 2.00 to 5.89 formal, with the cerium(III) and cerium(IV) concentrations maintained constant. The results were plotted as R against $[\text{H}^+]$ and the curve indicated that the rate of exchange became less dependent on the hydrogen ion concentration as the acid concentration decreased. Qualitatively this can be explained on the basis that at low acid concentration the total concentration of the hydrolyzed forms of cerium(IV) is relatively large and, therefore, the rate of exchange is not as dependent on the acid concentration when it is low compared to when it is high. Also, different hydrolyzed forms probably exist, including possibly more highly polymerized forms.

Extrapolation of the curve is the plot of R against $[H^+]$ yields the result that the rate approaches zero at high acid concentration, when essentially only the species $Ce(IV)$ is present. It was predicted on the basis of experimental results that in 5 to 6 formal perchloric acid the relative reactivity of the various hydrolyzed monomer forms of cerium(IV) with respect to electron exchange increases in the following order: $Ce(IV) < CeOH^{+3} < Ce(OH)_2^{+2} < Ce(OH)_3^+$.

It was observed that none of the following catalyzed the exchange reaction: platinum, platinum black, increased glass surface (glass beads), polyethylene surface, diffuse light, or molecular oxygen.

MECHANISM OF DISPLACEMENT OF HALOGEN
FROM AROMATIC NUCLEI BY NUCLEOPHILIC REAGENTS¹

LAWRENCE R. PARKS²
Department of Chemistry

The rates of the reaction of *N*-methylaniline with 1-*X*-2,4-dinitrobenzenes in which *X* is F, Cl and Br have been measured in nitrobenzene and in 99.8 per cent ethanol as solvents. In both media the order of reactivity, at the temperatures studied, is $Br > Cl > F$. This is the reverse of the usually found order of $F > Cl > Br$ for aromatic, nucleophilic substitution and is the order found for nucleophilic substitution at aliphatic carbons. Preliminary estimates show that variations in the entropies of activation make significant contributions to the relative reactivities. It is inferred that by increasing the steric requirements of the nucleophile and using a solvent with low solvating power, bond breaking must have progressed to a significant extent in the transition states.

The use of benzoate ions as nucleophiles has been studied in 60 per cent dioxane as solvent. Unsubstituted benzoate ions and ions with *para*-methoxy and *para*-nitro substituents were reacted with 1-chloro-2,4-dinitrobenzene and methyl iodide. Both reactions were found to be remarkably insensitive to substituent effects but the aromatic replacement was more sensitive than the aliphatic case. This evidence points to a transition state very close to reactants for this reaction.

Replacement of chloride from 1-chloro-2,4-dinitrobenzene with hydroxide ion in 60 per cent dioxane and 40 per cent water was appreciably slower than replacement by deuterioxide ion in 60 per cent dioxane and 40 per cent deuterium oxide. The exact nature of this isotope effect is not clear but it is believed to be due to more effective solvation by the latter solvent.

The reaction of phenol, triethylamine and 1-chloro-2,4-dinitrobenzene in benzene did not give the clean second order kinetics shown by all the above reactions. The rate depends on the concentration of all three reactants but is inhibited by added amounts of triethylamine hydrochloride, a reaction product. The kinetic data obtained best fit a mechanism based on the assumption that the products of a prior equilibrium between phenol and triethylamine are not tightly complexed. Infrared spectra of benzene solutions containing phenol and triethylamine show a large weakening of phenol OH bond stretching which must be due to complexing or ionization in benzene solution. The complexing is not tight because doubling the amine concentration with respect to the phenol concentration lowers the OH adsorption still further than when the two concentrations were equal.

¹Doctoral thesis no. 1618, submitted December 9, 1954. Chairman of Committee, George S. Hammond, Department of Chemistry.

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INHERITANCE OF RESISTANCE IN CORN TO LEAF FEEDING
OF THE EUROPEAN CORN BORER¹LOWELL H. PENNY²
Department of Agronomy

The purpose of the investigations reported herein was to obtain some information on the relative resistance to leaf feeding of the European corn borer of a considerable group of inbred lines of corn both as lines and in hybrid combination with a susceptible single cross tester. Additionally, an attempt was made to estimate the number of genetic factors for resistance and the average degree of dominance of those genes in segregating populations of crosses between inbreds differing widely in borer rating. Throughout the entire study a nine class rating scale was used for evaluating borer leaf feeding. In all experiments the ratings for corn borer resistance, whether on a plot or an individual plant basis, were made only on plants that had been manually infested with corn borer eggs.

Sixty-one inbred lines of corn and their crosses to the single cross tester 187-2 x M14 were assembled for a study of their relative resistance to leaf feeding of the European corn borer. The lines and the testcrosses were grown in separate randomized block experiments in both 1953 and 1954. On a 1 to 9 rating scale, mean ratings for the two years of test formed a nearly continuous distribution, ranging from 1.6 for 41.2504B to 8.2 for WF9. With very few exceptions, the lines received a more resistant rating than did the corresponding testcrosses. Genotypic correlations of 0.64 and 0.81 were obtained in 1953 and 1954, respectively, between the line ratings and the testcross ratings in the same year. Although the ratings of the lines were highly correlated with the ratings of the testcrosses of those lines, there was evidence that not all resistant lines transmitted equally their resistance to the crosses. It seemed reasonable to suspect that these lines carried different genes or numbers of genes for resistance and that these genes differed in their dominance relationships.

A study was made in 1953 of the segregation in F_2 and first backcross generations of the four susceptible x resistant crosses B14 x N32, B14 x MS1, B10 x MS1, and M14 x MS1. The M14 x MS1 cross was repeated in 1954. Infestations were low and variable in 1953 but were much higher and more uniform in 1954. Square root and logarithmic transformations were performed on the 1953 individual plant ratings in an attempt to eliminate the obvious correlation between means and variances on the observed scale of measurement.

Estimates of environmental variance derived from nonsegregating parental and F_1 populations were used to separate the total within-plot mean squares of F_2 and backcrosses into estimated genetic and environmental portions. Data from the F_2 and backcross generations furnished an estimate of the additive genetic variance as a proportion of the total F_2 variance. Variations of the Castle-Wright formula were used on each segregating population to estimate the number of gene pairs involved in borer resistance. In the B14 x N32, B14 x MS1, and B10 x MS1 crosses the F_1 was intermediate in rating between the two parents, but with a slight tendency toward the resistant parent; only one or two genetic factors for resistance appeared to be segregating; and estimates of the proportion of the total variance which was due to gene segregation in the F_2 were all 0.33 or larger, ranging up to 0.67. In both 1953 and 1954 in the M14 x MS1 cross the F_1 approached the susceptible parent in rating, and the estimates of gene numbers indicated at least three genetic factors for borer resistance differentiating the two lines. The estimates of the proportion of genetic variance in the F_2 were 0.21 to 0.26 in 1953 and 0.58 in 1954.

The segregation for borer resistance and susceptibility of F_3 and selfed first backcross progenies of the M14 x MS1 cross were studied in a replicated experiment in 1954. Low frequencies of resistant progenies in the F_3 and selfed backcross to MS1 and high susceptibility of the selfed backcross to M14 indicated that probably three or more genes were involved in the segregation with susceptibility dominant.

The degree of dominance of the genes conditioning borer resistance differences in the cross M14 x MS1 was estimated by two different methods in two experiments in 1954. For the first estimate of dominance the genetic variance of F_3 means was compared

¹Doctoral thesis no. 1631, submitted January 24, 1955. Chairman of Committee, G.K. Sprague, Department of Agronomy.

²B.S., Kansas State College, Manhattan, Kansas, 1943. M.S., *ibid.*, 1947.

with the sum of the genetic variances of the means of selfed backcrosses to both parents. The second estimate of the degree of dominance resulted from a relationship of two variance components obtained from the analysis of variance of plot means in an experiment composed of progenies arising from the backcrossing of F_2 plants to both parents. The estimates obtained were essentially zero in the first case and 0.20 in the second. In the latter, a statistical test of the hypothesis that dominance was lacking gave no basis for rejecting the hypothesis. Since additivity of gene effects over the loci involved is a basic assumption in both methods of estimating dominance, any interallelic interactions which might have been present could have affected the accuracy of the estimates.

SMALL ORDER EFFECTS IN BETA DECAY AND SOME DECAY SCHEMES¹

ARTHUR POHM²

Department of Physics

The beta spectra of K^{42} , As^{76} , and P^{32} were examined for small order effects with a thin-lens and an intermediate-image spectrometer. The first forbidden transition of K^{42} and As^{76} with zero spin changes were found to have allowed shapes within experimental error. This information was used to assign the magnitude of certain nuclear parameters.

The P^{32} activity was carefully examined for the presence of possible Fierz type deviations. Within experimental error, no deviation was found.

The activities of Eu^{152} and Eu^{154} were examined to determine beta groups and decay schemes. The decay of Eu^{154} was assigned one beta group of 838 ± 40 kev and 3 gamma rays of 340 ± 4 , 776 ± 4 , and 1115 ± 5 kev. The decay of Eu^{152} was assigned 4 beta groups of 1860 ± 10 , 1507 ± 10 , 650 ± 50 , and 440 ± 40 kev and gamma rays with energies of 123 ± 1 , 344 ± 1 , 190 ± 4 , 1250 ± 40 , 1415 ± 10 , and 876 ± 6 kev were tentatively assigned. Some gamma rays were left unassigned.

¹Doctoral thesis no. 1600, submitted September 16, 1954. Chairman of Committee, E.N. Jensen, Department of Physics.

²B.E.E., Fenn College, Cleveland, Ohio, 1950. B.E.S., Ibid., 1950. M.S., Iowa State College, Ames, 1953. Research Assistant, Institute for Atomic Research.

FACTORS AFFECTING THE RESISTANCE OF HOUSE FLIES TO INSECTICIDES¹

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The house fly, *Musca domestica* L., has developed a resistance to the action of DDT both in field populations and in selected laboratory strains. The purpose of this investigation was to determine the method of inheritance of resistance to DDT. Two strains of flies, varying in their ability to survive after treatment with DDT, were maintained as separate cultures. The susceptible strain was the 1952 NAIDM (now CSMA) strain obtained from the Rohm and Haas Company, Philadelphia, Pennsylvania. The resistant strain was started from eggs collected from female flies captured in 1952 at the Clemson College dairy barn, Clemson, South Carolina. These barns had been treated with DDT and other residual-type fly control materials since 1946. The laboratory cultures were reared and tested at 27°C.

¹Doctoral thesis no. 1605, submitted November 23, 1954. Chairman of Committee, C.H. Richardson, Department of Zoology and Entomology.

²B.S., Ohio University, Athens, Ohio, 1942. M.S., Iowa State College, Ames, 1947.

Crosses between the two strains were carried out by adapting the techniques developed for genetical research with Drosophila melanogaster Meig. Single pairs were mated by isolating a virgin female with the proper male in a one-quart jar. Eggs from these pairs were reared in CSMA larval medium modified by adding oat hulls and the necessary extra water. The adults were tested for susceptibility to DDT by topical application of an acetone solution to the dorsal surface of the thorax. Males and females were separated before treatment. The flies were scored for mortality after a 24-hour holding period.

In the susceptible strain mortality increased with an increase in dosage, but mortality in the resistant strain reached a maximum and additional increases in dosage failed to produce any further increase in mortality. There was no overlap in resistance of the two populations. The original resistant strain was cultured in the laboratory for nearly a year, 12 generations, with no noticeable loss of resistance to DDT.

A total of 11 crosses was made between a resistant male and a susceptible female. The level of resistance of the F_1 progeny fell between that of the two parental strains. Thus resistance was transmitted in a diluted form through the male to both sexes of the progeny. In the reciprocal cross 11 pairs were mated with similar results. In this case resistance was transmitted through the female to both sexes of the F_1 progeny. There was no significant difference in the resistance level of the F_1 generation from these reciprocal crosses.

An F_2 generation of adults was reared from the F_1 progeny in each case above. The level of resistance in the F_2 generation was similar to that of the F_1 in both types of crosses. Thus, DDT resistance was transmitted to both sexes of the F_2 generation regardless of whether resistance was introduced into the original cross from a resistant male or a resistant female. There was no tendency toward sex linkage of any major factors for resistance.

The resistance level dropped considerably when F_1 females from (resistant male X susceptible female) were backcrossed to susceptible females. When these progeny were again backcrossed to susceptible males the resistance level dropped even lower but was still above that of the susceptible parent.

As knockdown time or time for death to occur was not used in this investigation, genes controlling knockdown were not evaluated. The data obtained using mortality alone could not be fitted to any pattern of simple Mendelian inheritance. The inheritance of resistance in the Clemson strain of house flies pointed to some form of quantitative inheritance with no estimate of the number of factors involved.

The housefly has been considered to be fairly free of gene mutations producing observable differences in the phenotype. This may not be the case as two abnormalities were observed during the course of this investigation in addition to the main aberrant strain possessing resistance to the action of DDT. One case involved cultures reared from single pair crosses between the resistant and susceptible strain in which only males matured. A culture was considered to contain only males if no females were produced over the entire range of hatching. The males were fertile but when crossed with various females the situation did not reoccur. The case was not followed further.

The second case involved flies which had white eyes instead of the usual wild-type or red eyes. The culture of white-eyed flies was started from a single, gravid, white-eyed female discovered in the DDT-resistant colony. The adults reared from these eggs were all wild type in appearance. The following generation contained both male and female white-eyed flies which were isolated while still virgin to establish a pure culture. The line was continued for nearly two years, 24 generations, without contamination from outside flies although maintained in the same room with the wild type strains.

When crossed with the wild type the F_1 generation was all wild type, but white-eyed flies appeared in a 1 to 3 ratio in the F_2 generation and in a 1 to 1 ratio when the F_1 progeny were crossed back to white-eyed flies. Identical results were obtained from reciprocal crosses. Thus, white eyes behaved as a monofactorial character with no linkage to sex and was recessive to wild type in expression. No abnormalities in method of inheritance in the housefly were noted during the analysis of this gene.

RELATIVE TOXICITY OF SEVERAL NONPROTEIN
NITROGEN FEEDING COMPOUNDS FOR LAMBS¹WARD WILLIAM REPP²

Department of Animal Husbandry

The primary objective of this study was to find a nonprotein nitrogen compound which is less toxic than urea and which contains a nonnitrogen portion which can be utilized in the animal body. Other objectives included finding methods of alleviating symptoms of toxicity caused by administration of nonprotein nitrogen compounds and finding whether rumen microorganisms are capable of adapting themselves to increasing utilization of these compounds.

Ten nonprotein nitrogen compounds (urea, ammonium propionate, propionamide, ammonium formate, ammonium acetate, formamide, ammonium succinate, guanidine carbonate, biuret, glycine) and casein were administered orally to lambs to determine their relative toxicity. These compounds were administered in progressively larger doses and blood samples were taken at varying intervals following administration. Blood ammonia and urea determinations were made for each blood sample.

Blood ammonia values rose rapidly among those lambs drenched with urea, ammonium formate, ammonium acetate, and ammonium propionate. Blood urea values rose much more gradually. Toxicity in most instances was associated with large increases in blood ammonia levels, with the critical level about 1 mg per 100 ml. Fatal toxicity followed the administration of urea, ammonium propionate, ammonium acetate, and ammonium formate at a level of 40 gm of urea (or its nitrogen equivalent of the other compounds) per 100 pounds body weight. Fatal toxicity not associated with an increase in blood ammonia resulted from the administration of 30 gm urea equivalent of guanidine carbonate. When propionamide was administered to lambs which had not previously received this compound in the ration no increases in blood ammonia and only slight increases in blood urea were recorded even at the 80 gm level of administration. However, when lambs had received propionamide in the ration for 49 days, subsequent oral administration of 40 grams urea equivalent of propionamide resulted in slight increases in blood ammonia and urea; and when 80 gm urea equivalent of propionamide were administered to these lambs moderate increases in blood ammonia and urea were recorded. Administration of formamide at the 40 gm level and ammonium succinate at the 70 gm level caused only slight increases in blood ammonia and urea. Practically no rise in blood ammonia and urea attended the administration of guanidine carbonate, glycine, biuret, or casein.

Research was also initiated to study selected nonprotein nitrogen compounds as protein substitutes in lamb rations. This part of the investigation included two group feeding experiments, one individual feeding experiment, a nitrogen balance study and an *in vitro* adaptation study using the following compounds: urea, ammonium acetate, ammonium formate, ammonium propionate, propionamide, and formamide.

In the group feeding trials in which all nonprotein nitrogen compounds were added in amounts necessary to furnish 50 per cent of the protein equivalent, rates of gain for lambs fed urea, ammonium acetate, ammonium formate, and propionamide compared favorably with the conventional protein ration. In an individual lamb feeding trial in which propionamide and urea were fed at two identical levels (15 per cent and 30 per cent of the protein equivalent) the rate of gain for the lambs fed propionamide at the 30 per cent level were essentially the same as for the lambs receiving the conventional protein ration.

In *in vitro* studies propionamide was incubated with rumen microorganisms from lambs having received this compound in their ration for various lengths of time. It was found that the longer the lambs were on the propionamide ration the greater was the ability of their rumen microorganisms to release ammonia nitrogen from propionamide. These findings indicated an adaptation of the rumen microorganisms to utilization of propionamide nitrogen. The period required for full adaptation appeared to be about three weeks.

¹Doctoral thesis no. 1640, submitted March 9, 1955. Chairman of Committee, Wise Burroughs, Department of Animal Husbandry.

²B.S., Iowa State College, Ames, Iowa, 1941. M.S., South Dakota State College, Brookings, S.D., 1951. Graduate Assistant, Department of Animal Husbandry.

BOUNDEDNESS OF THE SOLUTIONS OF SOME
GENERAL NONLINEAR SECOND ORDER DIFFERENTIAL EQUATIONS¹DONALD EUGENE RICHMOND²

Department of Mathematics

Some new theorems on the existence of bounded and periodic solutions for ordinary second order differential equations are presented in this thesis. The equations considered are special cases of the general equation

$$\frac{d}{dt} \{a(x)\dot{x}\} + \dot{x}f(x, \dot{x}) + g(x) = e(t)$$

where the dot denotes differentiation with respect to the independent variable t . Three theorems are proved, dealing with different subclasses of this general equation. The proofs rest upon well-known theorems from the theory of topological transformations. The basic method was originated by Poincaré in the late nineteenth century and has been employed by numerous workers in recent years.

The primary difference between the results in this thesis and those of previous authors lies in the restrictions imposed on the "damping coefficient" $f(x, \dot{x})$. In previous papers it has been assumed that one or the other of two conditions is satisfied by $f(x, \dot{x})$. If the damping coefficient is a function of x alone, it has been commonly assumed that

$$\lim_{|x| \rightarrow \infty} \left\{ \left[\int_0^x f(u) du \right] \operatorname{sign} x \right\} = +\infty.$$

When the damping depends on both x and \dot{x} , the more severe restriction

$$\lim_{|x| \rightarrow \infty} f(x, \dot{x}) \geq L > 0$$

has been used. These assumptions are dispensed with in this thesis and the existence of bounded and periodic solutions is established for less restricted classes of functions $f(x, \dot{x})$. However, when these assumptions are given up, it is found that the other coefficients in the equation must be somewhat more restricted than they are in some previous papers.

Each theorem states that there exist fixed positive numbers X and \dot{X} such that every solution of the equation ultimately satisfies $|x| \leq X$, $\dot{x} \leq \dot{X}$. These bounds do not depend on the initial conditions $x(0)$ and $\dot{x}(0)$, but the time required for a solution to arrive within the rectangle which they define depends on where the solution starts. Each theorem also states that the differential equation has a periodic solution of period p if $e(t)$ is periodic of period p . This result is essentially a by-product of the proof of boundedness.

In all the theorems it is assumed that the coefficients satisfy conditions sufficient to assure the existence and uniqueness of solutions. In addition to this there are three assumptions which are common to all the theorems. These are as follows:

- (i) $a(x) > 0$ for all values of x .
- (ii) There exists a fixed positive number x_0 such that $xg(x) > 0$ for all $x \geq x_0$.
- (iii) $\lim_{|x| \rightarrow \infty} \left\{ \psi(x) \right\} = +\infty$,

where

$$\psi(x) = \int_0^x g(u)a(u)du.$$

Additional hypotheses differ for the three theorems.

¹ Doctoral thesis no. 1649, submitted April 18, 1955. Chairman of Committee, Carl E. Langenhop, Department of Mathematics.

² B.S., North Texas State College, Denton, Texas, 1948. M.S., Ibid., 1949. Graduate Assistant, Department of Mathematics.

Additional hypotheses for Theorem I are as follows:

- (a) There exists a fixed number δ such that $F(x) \geq \delta$ for $x \geq x_0$ and $F(x) \leq -\delta$ for $x \leq -x_0$, where

$$F(x) = \int_0^x f(u) du.$$

- (b) There exists a fixed positive number ε such that $|E(t)| \leq \delta - 2\varepsilon$ for all values of t , where

$$E(t) = \int_0^t e(u) du.$$

Additional hypotheses for Theorem II are as follows:

- (a) $f(x, \dot{x}) > 0$ for all $|x| \geq x_0$.

- (b) There exists a function $L(x)$ and fixed positive numbers \dot{x}_0 , λ , and δ such that $f(x, \dot{x}) > L(x) + 3\lambda$ for all $|x| \leq x_0$ and $|\dot{x}| \leq \dot{x}_0$, and

$$\int_{-x_0}^{x_0} L(u) du = \delta.$$

- (c) There exists a fixed positive number η such that $\Phi(x, \dot{x}) \geq \eta$ for $x \geq x_0$ and $\Phi(x, \dot{x}) \leq -\eta$ for $x \leq -x_0$, where

$$\Phi(x, \dot{x}) = a(x)g(x)/f(x, \dot{x}).$$

- (d) There exists a fixed positive number M such that $|E(t)| \leq M$, where

$$E(t) = \int_0^t e(u) du,$$

and

$$M < \min \left\{ 2\eta, \left(\frac{1}{2} \right) \delta \right\}.$$

Theorem III includes hypotheses (a) and (b) of Theorem II, plus the following:

- (c) $\lim_{|x| \rightarrow \infty} \{ [g(x)] \operatorname{sign} x \} = +\infty$.

- (d) There exist fixed positive numbers α and β such that $\chi(x, \dot{x}) \leq \alpha$ and $\chi(x, \dot{x}) |g(x)| \geq \beta$ for $|x| \geq x_0$, where

$$\chi(x, \dot{x}) = f(x, \dot{x})/a(x).$$

- (e) There exists a fixed positive number M such that $|e(t)| \leq M$, and M is smaller than a certain fixed number.

The bound on M in assumption (e) is developed in the course of the proof of Theorem III.

BETA SPECTRA OF SOME SHORT-LIVED NUCLIDES¹LAURENCE S. RING, JR.²

Department of Physics

The determination of the energy endpoints of the beta radiation spectra from the parent nuclides of 'mirror' pairs was undertaken utilizing an improved scintillation spectrometer as the means of detection. The Iowa State College 67 Mev synchrotron was used to create the short-lived parent nuclei, and a short pneumatic tube was used to transport the samples rapidly to the counting position.

The scintillation spectrometer was an improved version of the one reported in ISC-359 (1) and subsequently by Hunt (2). The detector consisted of two photomultiplier tubes and anthracene crystals arranged to give nearly complete solid angle response to the particles from the thin (40 mg/cm²) samples used.

The Cs¹³⁷ internal conversion peak was analyzed. The resolution of the peak was 15.9 per cent with a valley to peak ratio of 0.29. The P³², Y⁹⁰, and Cl³⁴ spectra, which have reported endpoint energies of 1.70, 2.24, and 4.47 Mev respectively, were examined to test the accuracy of the scintillation spectrometer and recording equipment. A calibration pulse height versus energy ratio was established by adjusting the Kurie plot from the recorded P³² negatron spectrum to have an endpoint energy of 1.70 Mev. The calibration ratio was then applied to the Y⁹⁰ negatron spectrum and the Cl³⁴ positron spectrum to determine their endpoint energies. The endpoint energies agreed with magnetic spectrometer values. This and additional spectral calibrations established that positron endpoints could be determined accurately with this equipment.

A table of reported experimental half-lives and positron energy endpoints for parent 'mirror' nuclei with atomic numbers greater than ten is included.

The positron endpoint energies obtained by the author, and the respective 'ft' values for the transitions are listed in Table 1.

Table 1. Endpoint kinetic energies, half-lives, and 'ft' values for some 'mirror' transitions.

Nucleus	E_{\max} (Mev)	$t_{1/2}$ (sec)	ft (sec)
Si ²⁷	3.82±0.04	4.47±0.05	4520±310
P ²⁹	3.82±0.04	4.46±0.05	4350±310
S ³¹	4.42±0.03	2.55±0.02	4640±250
Ca ³⁹	5.58±0.04	0.97±0.02	4830±230

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¹Doctoral thesis no. 1676, submitted June 6, 1955. Chairman of Committee, D.J. Zaffarano, Department of Physics.

²B.S., University of New Hampshire, Durham, N.H., 1950. Research Assistant, Institute for Atomic Research.

SOUND DISPERSION IN HALOGEN-SUBSTITUTED METHANES¹THOMAS DEAN ROSSING²

Department of Physics

When thermal disturbances occur very rapidly in a gas, as when high frequency sound is propagated through it, the vibrational and rotational modes of energy may fail to maintain thermal equilibrium with the translational energy. The resulting lag in the heat capacity causes the velocity of the sound to depend upon frequency throughout a certain range of frequencies. Thus, the measurement of ultrasonic velocities affords a precise method for measuring the relaxation time of energy exchange between translational, vibrational, and rotational modes.

The vibrational relaxation times of 14 halogen-substituted methanes have been measured using an acoustic interferometer of the Pierce type which employs a quartz crystal transducer and a movable reflector. Improved electronic circuits made precise measurements possible at very low gas pressures. All the gases were found to have a single relaxation time. This indicates that intermodal coupling is so strong that once the vibrational mode of lowest frequency has been excited, energy passes readily into the other modes. By application of gas kinetic theory, the average numbers of collisions necessary to excite molecular vibrations have been calculated. Excellent agreement has been obtained with the data of previous investigators in some of the gases.

The probability, in a given collision, of exciting or de-exciting vibrations has been predicted by Landau and Teller (1) to depend upon the relative velocity of approach of the molecules. The experimental data, when plotted according to this theory, predict an absurd value of $1/4 \text{ \AA}$ for the molecular interaction distance.

Following a suggestion of Fogg, Hanks, and Lambert (2), the probability of de-excitation is assumed to be a constant α if the relative energy of approach ϵ exceeds a critical value ϵ^* and zero if $\epsilon < \epsilon^*$. Integration over a distribution of energies results in an expression for the average number of collisions Z_{10} needed to de-excite a molecular vibration by converting vibrational energy to translational:

$$Z_{10} = \frac{1}{\alpha \left(\frac{\epsilon^*}{kT} + 1 \right)} e^{-\frac{\epsilon^*}{kT}}$$

In the above expression, k is Boltzmann's constant, T is the absolute temperature, and α is a steric factor which gives the probability that the colliding molecules will approach each other favorably oriented for energy transfer to take place. ϵ^* may be written as $nh\nu$, where ν is the frequency of the vibrational mode of lowest frequency.

Values of Z_{10} , when plotted according to this energy excitation theory, fall along four curves, each characterized by a single value of n . Molecules with no substitutions, those with one or two halogens, those with three, and those with four, fall on curves having values of $n = 1.5, 1.8, 2.8,$ and 3.8 , respectively.

Apparently ϵ^* represents the energy necessary for the colliding molecules to penetrate deeply into the force fields of each other and possibly to form compound molecules with extremely short lifetimes during which energy exchanges take place readily.

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¹Doctoral thesis no. 1573, submitted July 8, 1954. Chairman of Committee, Sam Legvold, Department of Physics.

²B.A., Luther College, Decorah, Iowa, 1950. M.S., Iowa State College, Ames, 1952. Research Associate, Engineering Experiment Station.

APPARATUS FOR STUDY OF ADSORPTION OF VAPORS ON MERCURY¹DORIS VIRGINIA STAGE²

Department of Chemistry and the Institute for Atomic Research

A pendent drop apparatus for the measurement of the surface tension of mercury and similar substances in high vacuum under conditions of maximum purity was designed, built, and demonstrated to be practical. Provisions for the admission of one or more vapors of high purity to desired partial pressures were incorporated.

The surface tension of purified mercury was found to be 460 ± 2 dynes/cm at 30°C . The presently accepted value is about 25 dynes/cm higher than this. The most probable explanation for this discrepancy is that, despite the precautions exercised, the purity of the mercury used in this work was not entirely satisfactory.

The dependence of surface tension lowering of mercury on the partial vapor pressure of *n*-heptane and of ethanol, both as pure components and from mixtures of the two vapors, was observed experimentally at 30°C . From these data adsorption isotherms were inferred.

A surface equation of state was developed, generalized to many components, and shown to be of approximately virial form. This equation was found to represent adsorption of the single components quite well, and adsorption from mixtures somewhat less well. The significance of these results with respect to molecular interactions was discussed.

¹Doctoral thesis no. 1652, submitted May 13, 1955. Chairman of Committee, Robert S. Hansen, Department of Chemistry.

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INSECTICIDE SEED TREATMENTS ON CORN AND SOYBEANS¹KENNETH J. STARKS²

Department of Zoology and Entomology

Greenhouse and field tests were carried out from 1952 to 1954, inclusive, to evaluate certain organic insecticides as seed treatments on corn and soybeans. The effects of these insecticides on both seed and seed-attacking insects were considered.

The principal criteria for measuring direct treatment effects on seeds and seedlings were mean emergence period, total emergence, average green weight per seedling, and lengths of primary roots. In most of the greenhouse work the seeds were germinated in greenhouse flats partly filled with washed river sand or a sand-soil mixture. Stand counts and yields were used to evaluate insecticide seed treatments in hand-planted field experiments. Wireworm counts from traps baited with either spoiled corn or a mixture of corn meal and graham flour were used to compare field-scale treatments in commercial fields.

Seed for greenhouse work and hand-planted field plots was treated in either pint or quart fruit jars. The jars were shaken by hand and rotated on a laboratory mixer to distribute the chemicals uniformly over the seed. Seed for field-scale experiments was treated in either a 10-gallon milk can or a concrete mixer. Methyl cellulose solution was usually used on both large and small lots as an adhesive for any dry ingredients.

Acetone as a solvent for applying lindane seed treatments caused a progressive reduction in stand and yield of Pioneer Hybrid 379 corn as the dosage of insecticide was increased. This injury was not lessened appreciably by the addition of either

¹Doctoral thesis no. 1596, submitted August 24, 1954. Chairman of Committee, J.H. Lilly, Department of Zoology and Entomology.

²B.S., University of Oklahoma, Norman, Oklahoma, 1950. M.S., Ibid., 1951. Graduate Assistant, Agricultural Experiment Station.

captan or thiram. Pioneer Hybrid 339 seed showed the same trend but to a much less marked degree under field conditions. Neither variety of corn was injured to any extent when lindane was applied in a wettable powder formulation with methyl cellulose as a sticker. Methyl cellulose as an adhesive for lindane was superior to dry applications of lindane in greenhouse tests. Under these conditions there was a progressive decrease in lengths of the primary roots of corn seedlings as the dosage of insecticide was increased from 1/16 to 1 ounce of active ingredient per bushel of seed, either with or without the sticker.

Most of the wettable powder formulations of insecticides that were tried on corn were safe to the seed, but practically all of the corresponding emulsifiable concentrates at comparable dosages were somewhat phytotoxic. Malathion and Dow DN-111 were both highly injurious to soybeans but not to corn at the same dosages. Soybean seed deteriorated during prolonged storage and thus became more susceptible to insecticide seed treatments. Soybeans of high viability were more tolerant of emulsion applications of several insecticides and of BHC wettable powder seed treatment than was corn. Corn seedlings grown in soil in a preliminary test overcame a deficiency in green weights caused by a high dosage of lindane within 18 days. The primary roots of seedlings in the lindane treatment were still slightly shorter than those in the control treatment at the end of the experiment but there were ample secondary roots on the seedlings from insecticide-treated seed.

The clubbing of the primary roots of corn seedlings by lindane was not lessened by concentrations of dextrose ranging up to 9.125 ounces per bushel of seed when seeds were germinated in sand. Two antibiotics, streptomycin and Terramycin, used in water dips at dosages ranging from 3 to 24 ppm did not noticeably influence the germination and growth of corn planted in a soil-sand mixture in the greenhouse. No insecticides were used in this preliminary experiment.

In field experiments subjected to cool, damp weather captan apparently was fully compatible with the insecticides and it also significantly increased the stands of both corn and soybeans. Under these conditions this fungicide showed indications of reduced injury to soybeans caused by 1-ounce dosages of certain insecticides, particularly Diazinon. Captan applied to soybeans of an old seed lot caused stunted growth and adherence of the seed integuments to the cotyledons for several days after they normally would have been shed. The addition of lindane to the captan treatment increased the injury. This injury was found to be caused by a reduction in seed viability, rather than prolonged contact of chemicals on the seed.

Seed treatments with Diazinon, lindane, and heptachlor gave significant increases in soybean stands where maggot injury was common. No difference was detected in the protection afforded by 1/3-, 2/3-, and 1-ounce levels of the insecticides, either alone or in combination with captan. Moistened fish meal was used to attract seed-corn maggot adults to planted soybeans after previous tests without baiting failed to show sufficient damage to permit treatment evaluations.

Lindane, toxaphene, dieldrin, and heptachlor all appeared to be compatible with a proprietary soybean inoculant, on the basis of visual inspection of the plots and harvested yields. Insecticides were responsible for a small but statistically significant increase in the iodine number of the soybean oil, but did not significantly influence the oil content of the harvested beans. Lindane without inoculant was mainly responsible for this increase in iodine number by insecticide seed treatment.

Lindane seed treatment failed to protect corn seedlings satisfactorily from wireworm attack in a field test at Centerville in 1952. Combination seed and soil treatments in the replanting gave significant increases in stands but not in yields. There was a decline in wireworm feeding as the season advanced, and a greater amount of pupation during the latter part of the summer.

Heptachlor, dieldrin, and lindane were effective in protecting germinating seed corn against wireworms at 1 ounce of actual ingredient per bushel of seed, and against *Agonoderus* spp. and *Clivina impressifrons* at 1/2 ounce per bushel. Diazinon killed about as many insects as the above three insecticides, but failed to prevent seed damage satisfactorily. Toxaphene was not effective in protecting corn seed.

Melanotus communis larvae and *Agonoderus* spp. adults damaged soybeans slightly in laboratory tests, but apparently they prefer corn as a source of food.

SOURCES, INHERITANCE, AND LINKAGE RELATIONSHIPS OF
RESISTANCE TO RACE 4 OF LEAF RUST (*PUCCINIA HORDEI* OTTH.),
RACE 9 OF POWDERY MILDEW (*ERYSIPHE GRAMINIA HORDEI* EL MARCHAL.),
AND CERTAIN AGRONOMIC CHARACTERS IN BARLEY¹

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The major objective of the barley breeding project in Virginia is the development of varieties which are high yielding, stiff strawed, awnletted or awnless, and resistant to the major diseases, including leaf rust and powdery mildew. The purposes of the investigations reported herein were to isolate sources of resistance to the prevalent races of these two disease organisms in Virginia, and to study the inheritance and linkage relationships of resistance to race 4 of leaf rust, race 9 of powdery mildew, and certain agronomic characters in barley.

The leaf rust reactions of 374 varieties of barley were determined under field and greenhouse conditions. Field reactions were based on natural infection, and race 4 was used in the greenhouse studies. Out of the 147 varieties found to be resistant, 44 originated from North Africa and 48 originated from European countries. Eighteen of the 48 from Europe came from Turkey, and eight each came from Spain and France.

Among 391 varieties of barley classified in the seedling stage under greenhouse conditions for reaction to race 9 of powdery mildew, 228 were resistant or mixed resistant and susceptible. The sources of the resistant varieties revealed that 108 came from Asiatic countries, 48 from European countries, and 35 from countries in North Africa. India was the source of 39 and Japan 18 of those from Asiatic countries. Turkey was the source of 25 of those from European countries. Over ten per cent of all varieties with resistance to leaf rust and of those with resistance to powdery mildew came from Turkey.

The Cereal Investigations or Plant Introduction numbers of varieties having high resistance to both race 4 of leaf rust and race 9 of powdery mildew are as follows: 2483, 2524, 3212-1, 3400, 3401, 3527-2, 3528, 3530-2, 3609, 3614, 3623, 3725, 4219, 4220-1, 4291-2, 4356, 4974, 4979, 5529, 5557, 5559, 5862, 6168, 6193, 6448, 7748, 7845, 170939, 178630, 180669, 180672, and 180691.

The inheritance of resistance to race 4 of leaf rust was studied in resistant x susceptible crosses involving 13 resistant varieties. The leaf rust reaction of F_1 plants of all crosses, except those involving Cebada Capa, was intermediate between the resistant and susceptible parents. Resistance from Cebada Capa was completely dominant. Quinn, Carre 180, and probably C.I. 3530-2 each had two independent factor pairs for resistance. Resistance from Modia, Batna, Cebada Capa, C.I. 2524, C.I. 6306, Peruvian, C.I. 3895-2, Chilean C, and Chile Brewing was inherited on the basis of a single factor pair.

Segregates susceptible to leaf rust were not obtained from crosses of resistant Peruvian with resistant Batna, Juliaca, C.I. 6306, Carre 180, C.I. 3530-2, and 3895-2, indicating that all have a factor for resistance at the Pa locus. Susceptible segregates were obtained from crosses of resistant Cebada Capa and C.I. 2524 with resistant Peruvian, indicating that the factors for resistance in these two varieties are not at the Pa locus.

The inheritance of resistance to race 9 of powdery mildew was studied in resistant x susceptible crosses involving eight resistant varieties. C.I. 4974 had two independent dominant factor pairs for resistance, and Modia, Batna, Cebada Capa, C.I. 2524, C.I. 6306, C.I. 3530-2, and C.I. 4979 each had a single dominant factor pair. Crosses involving C.I. 6306, Modia, and C.I. 3530-2 were studied for inheritance or resistance to races 3, 4, and 11, in addition to race 9. The same factor giving resistance to race 9 in each of these varieties also gave resistance to races 3, 4, and 11. Modia and C.I. 3530-2 each had an additional independent factor for resistance to races 3 and 4 only. No linkage was found between factors for resistance to powdery mildew and those for resistance to leaf rust.

The inheritance of winter versus spring growth type was studied in 34 crosses.

¹Doctoral thesis no. 1636, submitted March 4, 1955. Chairman of Committee, I. J. Johnson, Department of Agronomy.

²B.S., Virginia Polytechnic Institute, Blacksburg, Virginia, 1944. M.S., Iowa State College, Ames, 1947. Graduate Assistant.

A single factor pair appeared to determine growth type, with spring growth type being dominant. Growth type was inherited independently of resistance to leaf rust in all crosses except those involving Chilean C and Chile Brewing. There appeared to be some linkage between spring growth type and resistance to leaf rust in these two varieties, but further study will be needed to establish the degree of linkage. Growth type and resistance to powdery mildew were inherited independently of each other in all crosses studied.

The inheritance of rough versus smooth awns was studied in five crosses, and was determined in each by a single factor pair, with rough awns dominant. Awn type was inherited independently of resistance to leaf rust and powdery mildew, but was linked with winter versus spring growth type with 39.3 ± 2.14 per cent crossing over.

The need for additional studies of environmental effects on the expression of resistance by different allelic and nonallelic factors for leaf rust and powdery mildew resistance was discussed.

HERITABILITY AND INTERRELATIONSHIP OF SOME QUANTITATIVE
CHARACTERS IN A CROSS BETWEEN TWO VARIETIES OF *GOSSYPIMUM HIRSUTUM*¹

LEE STREET STITH²

Department of Agronomy

To compete with the synthetic fiber, the cotton fiber must possess specialized properties not present in many commercial varieties grown today. The cotton breeder must go beyond the range of commercial varieties to obtain the genetic variability from which to select for new properties. Knowledge of how various agronomic characters are inherited and related is needed to wisely use diverse genetic material. The cross between Acala, a commercial Upland variety, and Hopi, a wild aboriginal variety, furnished the material for this study. These varieties differed widely in the characters studied, which gave opportunity for maximum expression of gene recombinations.

Heritabilities and interrelationships were studied for the following agronomic characters: 1) lint percentage, 2) boll size, 3) staple length, 4) fiber strength, and 5) fiber fineness. These characters all proved to be quantitatively inherited, with no evidence for transgressive segregation. Partial dominance was found for high lint percentage, large boll size, and longer fibers with no dominance for fiber strength and lack of dominance for coarse fibers. Estimates of gene number indicated boll size and staple length were controlled by a relatively large number, whereas other characters were controlled by a small number.

Heritability estimates were made from the genotypic variance of the F_2 population and from the variance components among F_3 lines. Heritability values from the F_2 population in per cent were 45.3 for lint percentage, 50.1 for boll size, 22.2 for staple length, 54.1 for fiber strength and 74.6 for fiber fineness. Based on the variance components, heritability values in per cent were 79.0 for lint percentage, 62.5 for boll size, 70.0 for staple length, 87.3 for fiber strength, and 69.9 for fiber fineness.

Significant phenotypic correlations were found in the F_2 lint percentage and fiber strength and for staple length and fiber fineness. Genotypic correlation for these characters in the F_2 were lower, suggesting that the actual genetic gain would not always be as rapid as expected.

In the F_3 population, significant phenotypic correlations were observed between lint percentage and staple length, boll size and fiber strength, boll size and fiber fineness, staple length and fiber strength, and staple length and fiber fineness. Of these phenotypic correlations, the relationship of lint percentage and staple length, staple length and fiber strength, and staple length and fiber fineness could have been predicted from the F_2 genotypic correlations. The genotypic correlation in the F_2 for boll size and fiber strength was opposite to phenotypic expression in F_2 and F_3 populations. Phenotypic selection for either character would have resulted in a genetic loss rather than gain.

¹Doctoral thesis no. 1632, submitted January 26, 1955. Chairman of Committee, I. J. Johnson, Department of Agronomy.

²B.S., New Mexico A. and M. College, State College, N. Mex., 1940.

M.S., University of Tennessee, Knoxville, Tenn., 1942.

Boll size and fiber strength, boll size and fiber fineness, and fiber strength and fiber fineness showed genotypic correlations opposite to the phenotypic and the desired correlations in most instances. One explanation is to postulate that pleiotrophy was present in the expression of fiber strength and fiber fineness under environment resulting in small boll size.

The relationship between staple length, fiber strength, and fiber fineness is not clear to the cotton breeder. Partial regression and partial correlation coefficients indicated these characters were related to the extent that selection for longer fibers would result in stronger and finer fibers. The lowest relationship was between fiber strength and fiber fineness.

Based on the results of this study a program of improvement for each of the characters studied should give consideration to the following points: 1) there is a negative relationship between lint percentage and other fiber properties, which would need to be broken, 2) based on the genotypic correlations in the F_2 population, selection for large boll size would result in longer, stronger, and finer fibers, but in low lint percentage, and 3) if fiber fineness is of primary consideration, early selection could be made for this character, and to a large extent on a single plant basis. The early generation selection for fineness should be followed with selection for staple length and fiber strength. Progeny row testing should be the most effective way to evaluate all characters except fiber fineness.

ITERATIVE PROCEDURE FOR OBTAINING THE PERIODIC SOLUTION OF CERTAIN NONLINEAR DIFFERENTIAL EQUATIONS¹

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The thesis concerns electric networks in which the Ohmic resistors have been replaced by quasi-linear resistors. A quasi-linear resistor is defined to be a conducting element which exhibits a potential drop having a derivative bounded between positive constants. All inductance coils and condensers in the network obey the usual linear laws. Such a network shall be termed a quasi-linear network. All impressed electromotive forces are assumed to be periodic functions of the time. The primary effort of the thesis is to exhibit and justify an iterative technique for obtaining the periodic solution of the quasi-linear network of equations.

A quasi-linear circuit with one degree of freedom is considered first. The differential equation satisfied by the current x is put in the form

$$(1) \quad \frac{d^2x}{dt^2} + \alpha \frac{df(x)}{dx} + \beta x = \frac{dE(t)}{dt}.$$

Here $f'(x)$ is assumed continuous and $0 < p \leq f'(x) \leq 1$. α and β are real, nonzero constants. It is assumed that $E(t)$ is absolutely continuous and of period 2π , and that $E'(t)$ belongs to the class $L_2(0, 2\pi)$ of Lebesgue measurable and Lebesgue integrable square functions.

Before introducing the iteration procedure, the equation (1) is written in the equivalent form

$$(2) \quad \frac{d^2x}{dt^2} + \alpha \frac{dx}{dt} + \beta x = \frac{d}{dt} \left\{ E(t) - \rho g(x) \right\}$$

where $\rho = \alpha(p-1)$ and $g(x) = x - f(x)/(1-p)$. It develops later that the addition of the term $\alpha dx/dt$ to both members of (1) is a "convergence improving" technique.

The iteration scheme consists in solving successive linear differential equations.

¹Doctoral thesis no. 1641, submitted March 9, 1955. Chairman of Committee, Carl E. Langenhop, Department of Mathematics.

²B.S., Montana State College, Bozeman, Mont., 1944. S.M., Massachusetts Institute of Technology, Cambridge, Mass., 1949. Instructor, Department of Mathematics.

The solution of (2) with g deleted is the first approximation of $x_0(t)$. Substitution of $x_0(t)$ into the right member of (2) gives the equation whose solution is $x_1(t)$. A repetition of this procedure gives successive iterates. The question of existence of the iterates $x_k(t)$ is settled and it is proved that $x_k(t)$, as well as $g(x_k(t))$, has a Fourier series representation. The Fourier constants of $x_{k+1}(t)$ are shown to be

$$(3) \quad x_n^{(k+1)} = \frac{\ln(E_n - g_n^{(k)})}{\beta - n^2 + i n \alpha} \quad (n = 0, \pm 1, \pm 2, \dots)$$

where E_n and $g_n^{(k)}$ are the Fourier constants of $E(t)$ and $g(x_k(t))$ respectively. $g_n^{(k)}$ is given by

$$(4) \quad g_n^{(k)} = 1/2\pi \int_0^{2\pi} r(x_k(t)) e^{-int} dt \quad (k = 0, 1, 2, \dots).$$

The iteration can be carried out in terms of the Fourier constants. The initial sequence of Fourier constants if $x_n^{(0)} = \ln E_n / (\beta - n^2 + i n \alpha)$. Then (4) with $k = 0$ is used to calculate the $x_n^{(1)}$.

The sequences of Fourier constants of the iterates are shown to belong to H_0 , the classic Hilbert space of sequences $\{x_i\}$ such that $\sum_i |x_i|^2$ converges. The sequence or

infinitetuple of Fourier constants of $x_k(t)$ is denoted by \vec{x}_k and it is verified that the sequence $\{\vec{x}_k\}$ is a Cauchy sequence in H_0 . Completeness of the space H_0 is used to show the existence of a limit in H_0 . That the limit function satisfies the differential equation is proved.

A general quasi-linear network with N degrees of freedom is considered. The linear network equations are

$$(5) \quad L \frac{d^2 \vec{x}}{dt^2} + R \frac{d \vec{x}}{dt} + S \vec{x} = \frac{d \vec{E}(t)}{dt}$$

where R and S are real, symmetric, positive semi-definite matrices, L is real, symmetric and positive definite, and \vec{x} is the vector of cyclic currents. If i_j is the branch current through the j th resistor, replacement of the potential drop $r_j i_j$ by $v_j(i_j)$ leads to the replacement of $R(d\vec{x}/dt)$ in (5) by a vector function $\vec{V}(\vec{x})$. If V^i denotes a matrix defined by the v_j^i in the same way that R is defined by the resistances r_j , then $\vec{V}(\vec{x}) = V^i \vec{x}$. The v_j^i are assumed continuous and the components of $\vec{E}(t)$ satisfy the same conditions as $\vec{E}(t)$ in the single circuit case.

In (5), the damping term is replaced by $\vec{V}(\vec{x})$ and transposed to the right member. As in the single circuit problem, a linear derivative term is then added to both members. The equation considered is

$$(6) \quad L \frac{d^2 \vec{x}}{dt^2} + A \frac{d \vec{x}}{dt} + S \vec{x} = \frac{d}{dt} \left\{ \vec{E}(t) + \vec{U}(\vec{x}) \right\}$$

where $\vec{U}(\vec{x}) = A \vec{x} - \vec{V}(\vec{x})$ and A is a constant matrix chosen positive definite. An iteration procedure similar to that for the single circuit case is employed. An existence theorem is proved for the linear systems arising in the iteration. It is proved that the

procedure converges to the solution whenever the condition $(\sum_r \sum_s \gamma_{rs}^2) (\max_n \lambda_n^2) < 1$ is satisfied. Here the γ_{rs} are upper bounds on the absolute values of the entries of $A - V^i$. The λ_n are the characteristic roots of the matrix $(|m_{rs}^{(n)}|)$ where $(m_{rs}^{(n)}) = \ln(-n^2 L + i n A + S)^{-1}$. Known results on limits for characteristic roots of matrices are used to replace this convergence condition by less sharp but more easily applied conditions. These results are illustrated by two specific examples.

CAPILLARY FRINGE AND WATER FLOW IN SOIL¹DALE SWARTZENDRUBER²

Department of Agronomy

The capillary fringe as defined in this study is a zone of porous medium which is 1) essentially saturated with water, 2) under tension, and 3) in immediate contact with a saturated zone in which the pressure in the water is greater than atmospheric. In the usual cases, the capillary fringe is located directly above the subsoil water table.

For a horizontal falling water table, the capillary fringe was analyzed theoretically on the basis of a falling meniscus in a capillary tube. It was found that the presence of the fringe retarded the flow as compared to that occurring without a fringe. Experimental data from the literature supported this conclusion.

The fringe was further investigated with laboratory flow models filled with sand or soil. The first model consisted of a semicircular arch constructed as a capillary siphon. It could be operated to work as either a system everywhere under hydrostatic pressure, or as a tension system simulating the capillary fringe. The mathematical solution for the flow was easily obtained using methods of potential theory.

The results from this model indicated that the head distribution along the outer boundary was practically unaffected when the operation of the model was shifted from hydrostatic pressure conditions to fringe conditions. Likewise, the hydraulic conductivity decreased only a small amount provided that essential saturation was maintained throughout the model.

The second model was rectangular in shape and contained a water reservoir at each end, with porous medium between the reservoirs. By ponding water in the reservoirs and maintaining a small head difference between them, the effect of the fringe for horizontal flow could be determined. In addition, the problem was solved mathematically, assuming the hydraulic conductivity to be the same both above and below the water table. An exact solution was obtained in elliptic integrals.

Experimental results with sand verified the theoretical solution for the rectangular model. As an example, consider the case in which the part of the soil column beneath the water table is one-tenth as high as it is long. It was found that the theory predicts a maximum flow contribution from the fringe of 170 per cent when compared to the flow occurring beneath the water table. This was verified experimentally. Furthermore, with respect to hydraulic conductivity and the distribution of head along the fringe boundary, the experimental results for the rectangular model were in agreement with those found for the semicircular model.

For soil, the fringe contribution to the flow seemed to be masked by variations in compaction. However, supplementary studies indicated that flow in the fringe for the case of soil would be correctly described by the theoretical solution if the compaction error did not exist.

The mathematical solution was derived for isotropic flow, but the theory can be extended to include the anisotropic case wherein the hydraulic conductivity of the medium is not independent of the direction of flow. For anisotropy in which the horizontal conductivity is greater than the vertical, which is the more common case in soil, the flow contribution of the fringe is reduced as compared with the isotropic case. When the vertical conductivity is greater than the horizontal, the fringe contribution is increased as compared to the isotropic case. Both results are easily explained qualitatively by considering the flow resistance encountered along a streamline which passes through the fringe.

In horizontal flow, the shape of the water table is altered by the presence of a capillary fringe. The most prominent feature is an upward bulge near the outlet boundary of the flow region. Apparently the bulge is necessary to drive the fringe flow through the outlet boundary beneath the water table.

Hysteresis also affects the flow contribution of the capillary fringe. This is largely a matter of the height of the fringe. This height will be greater if the porous medium is first saturated under pressure and the water table subsequently lowered. A smaller height results if the porous medium wets by capillarity from a water table maintained

¹Doctoral thesis no. 1622, submitted December 10, 1954. Chairman of Committee, Don Kirkham, Department of Agronomy.

²B.S., Iowa State College, Ames, Iowa, 1950. M.S., Ibid., 1952. Graduate Assistant.

at a constant level. The differences in fringe height and fringe contribution to the flow were demonstrated experimentally with sand. No measurements were made for soil.

Experimental and theoretical studies were conducted on reducing the flow in an existing capillary fringe by inserting plates into the medium perpendicular to the direction of flow. It was found difficult to reduce the flow by such means; that is, a relatively large number of plates is required to reduce the flow in the capillary fringe to a negligible amount. Hence, it is concluded that natural barriers in the fringe, such as cracks, crevices, or work holes, will not greatly reduce the flow contribution of the fringe.

Some of the experimental studies indicated that even the flow in the unsaturated zone above the fringe cannot always be neglected. However, the detailed study of this effect is left to future investigation.

No general solution for the flow contribution of the capillary fringe can be given. In all cases the capillary fringe increases the size of the conducting region. However, this size increase and the flow velocities through it will depend upon the boundary conditions of the specific problem.

RELATIONSHIP OF A SWINE PLEUROPNEUMONIA-LIKE ORGANISM TO INFECTIOUS ATROPHIC RHINITIS IN SWINE¹

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A pleuropneumonia-like organism was recovered from the nasal cavities of swine with infectious atrophic rhinitis. A preliminary report of this finding was published by Switzer (J. Am. Vet. Med. Assoc. 123:45, 1953) and is the first report of the occurrence of a pleuropneumonia-like organism in swine. It was possible to grow the swine pleuropneumonia-like organism in chicken embryos and in ox-heart-infusion/chicken-serum medium. Cultures of this organism inoculated intranasally into baby pigs produced no turbinate atrophy even though the organism became established in the nasal cavities of the pigs. When this organism was inoculated intraperitoneally into young pigs a pericarditis, pleuritis, peritonitis, and arthritis resulted. The swine pleuropneumonia-like organism was recovered from several field cases with similar lesions establishing that it causes pericarditis, pleuritis, peritonitis, and arthritis in field swine.

The swine pleuropneumonia-like organism was recovered from 64 of 96 (66.7 per cent) swine nasal cavities with turbinate atrophy and from 52 of 90 (57.8 per cent) swine nasal cavities with no turbinate atrophy. This indicates that it is not possible to correlate the occurrence of this organism with the occurrence of turbinate atrophy.

When the swine pleuropneumonia-like organism was inoculated into chickens, turkeys, mice, rabbits, guinea pigs, a calf, and a sheep, no significant lesions occurred. In addition 1-day-old mice and 7-week-old kittens developed no lesions when inoculated intranasally with crude atrophic turbinate suspensions.

The characteristics of the swine pleuropneumonia-like organism are typical of the pleuropneumonia group of organisms.

A histological study of atrophic turbinates indicated the basic lesion responsible for the turbinate atrophy is dedifferentiation of the osteoblasts and osteocytes into more primitive type cells that are morphologically indistinguishable from fibrous connective tissue. This dedifferentiation is accompanied by resorption of the bone salts precipitated in the matrix of these cells.

Several research workers have reported that *Pasteurella multocida* alone or in combination with *Spherophorus necrophorus* produces turbinate atrophy. It was demonstrated that neither of these organisms was associated with turbinate atrophy in the isolated infected herd used in this study. Thus, the present work described a hitherto unknown disease agent from swine, but it does not elucidate the etiology of infectious atrophic rhinitis.

¹Doctoral thesis no. 1617, submitted December 9, 1954. Chairman of Committee, R.A. Packer, Department of Veterinary Hygiene.

²D.V.M., Texas A. and M. College, College Station, Texas, 1948. M.S., Iowa State College, Ames, 1951. Assistant Professor, Veterinary Medical Research Institute.

TIMING OF CONSERVATION RETURNS¹JOHN W. THOMAS²

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This study of three hilly 160-acre owner-operated farms in the Ida-Monona soil association of western Iowa was to determine:

1. The time required for a high level of production to be obtained after the application of a recommended soil management plan.
2. The income each year from a revised soil management plan for a cash grain and eight livestock systems and from identical systems under the present plan, using both steady and declining prices throughout the transition period.
3. The amount of capital needed and the time required before additional income could repay the conservation investment.
4. The present value of future income at various discount rates.
5. The variation in gross income for a cash grain system from 1930 to 1949 compared with the variation in gross income under a conservation plan, after assuming the same percentage variation in climatic and price conditions.

This study analyzed the effect of using conservation practices in detail from 1952 to 1967 by budgeting each of three case farms under present soil management practices and a revised soil management plan for steady (1952 level) and declining prices (until 1958). In addition to a cash grain system, eight livestock systems often used in this area were employed to use all farm grown feeds.

Investment requirements for all combinations of both the revised and present plans were examined. The number of years required for the additional income from conservation to retire the additional expenditures for the revised plan was determined. Types and sources of credit were discussed in view of the needs for each farm.

These results show that a conservation plan was not profitable in the short run because crop production and income were temporarily reduced during the first part of the transition period. This income reduction was due primarily to the reduction in corn acreage, which decreased grain production. A larger forage acreage was necessary to conserve soil resources for future high production. Forage production was relatively low the first two transitional years because the seedings were not yet established. After the first two years of a 16-year period forage production will double or triple that of the present plan. Therefore, throughout the early transition period forage constituted an increasing proportion of the total feed units. In this study, the residual effects of better mechanical practices, fertilizers and improved rotations caused a higher total feed unit production on Farms No. 2 and No. 3 after several years under the conservation plan. However, on Farm No. 1 the beneficial effects of soil conservation did not compensate for the large reduction in grain acreage.

Farm returns were increased by processing all forage and grain crops through livestock. When the conservation plan was used, cattle numbers were increased considerably to utilize the available forage production. When grain was the major crop, as under the present plan, hogs were the main enterprise. The net income from all systems was lower than that of the present plan for three to seven years after the soil management plan was adopted. Grain production was so drastically limited to control erosion that the income from the cash grain and beef herd systems for Farm No. 1 under the revised plan was never as high as under the present plan. However, it is not likely that production can be maintained indefinitely under the present plan. All systems on Farms No. 2 and No. 3 and the other seven systems on Farm No. 1 processed the field crops through livestock at a profit.

The adoption of a conservation plan may depend largely upon the rate at which future income is discounted. If the discount rate is only 5 or 10 per cent, a soil conservation

¹Doctoral thesis no. 1623, submitted December 10, 1954. Chairman of Committee, Earl O. Heady, Department of Economics and Sociology.

²B.S., Iowa State College, Ames, Iowa, 1949. M.S., *Ibid.*, 1951. Graduate Assistant.

system usually will be profitable sometime before the transition period is completed. But, if the discount rate is 20 or 30 per cent, a continuation of present soil management practices is more profitable.

The expected price trend is also a determining factor as to whether a conservation program becomes profitable. A revised plan is more profitable if prices are rising. However, if prices are expected to drop materially the economic incentive to adopt a conservation plan diminishes.

Fluctuations in price and climatic conditions have caused farm income to be highly unstable. A conservation program alleviates this problem only to the extent that income fluctuates at a higher level. During years of low income capital for investments is limited--thus future income is perhaps discounted by an individual at different rates under varying conditions.

This study indicates that under normal conditions most of the systems have a sufficient positive return under a conservation plan to replenish the temporary loss in income and to repay the additional investment and interest (5 per cent) before the end of the transition period. However, a conservation type of farming is retarded even though its advantages are recognized to the extent that alternative short term investments have higher returns, or the operator has immediate financial commitments. Thus, the additional capital needed for terraces, fertilizers, legume seeds, and livestock purchases under the conservation plan may need to be borrowed. Even operators with capital to invest may hesitate to do so because of the risk involved in waiting for the additional revenue.

The author would like to see the Federal agricultural policy designed to promote conservation farming on a broader scale. The objective of such a policy should be to reduce the present surplus production while improving soil fertility for expanding future production. Such a policy, to be effective, would necessitate long-term compliance contracts between the farm operator and the government.

PURIFICATION AND CHARACTERIZATION OF A FUNGAL GLUCOSIDASE FROM *ASPERGILLUS NIGER*¹

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Recently, the importance of amylglucosidase from molds in the hydrolysis of starch has been emphasized. The presence of this glucosidase in fungal enzyme preparations has offered an explanation for the increased yields of sugar from starch and of alcohol from grains when molds are used instead of malt for saccharification.

A procedure was developed during this investigation for the purification of the glucosidase from *Aspergillus niger* NRRL 330. This strain of mold has been reported to produce high yields of alcohol as a saccharifying agent, and enzyme preparations from it are known to be high in amylglucosidase activity.

Mercuric acetate was found to precipitate much of the unwanted materials from the crude enzyme solution when added at a concentration of 3.75×10^{-3} molar. It was observed that the glucosidase is not inactivated nor inhibited by various heavy metal salts under the conditions in which the experiments were done. The alpha-amylase content in the crude mold filtrate was decreased by 60 per cent after the mercuric acetate treatment.

Precipitation of the glucosidase by organic solvents appeared to require the presence of some inorganic ions. When a partially purified solution of the mold glucosidase, which previous to dialysis could be precipitated by acetone, was dialyzed, no precipitation could be achieved by the addition of any amount of acetone. That the glucosidase was not lost or denatured by dialysis was indicated by its ability to precipitate with acetone after addition of ammonium sulfate to the dialyzed solution.

¹Doctoral thesis no. 1680, submitted June 6, 1955. Chairman of Committee, L.A. Underkofler, Department of Chemistry.

²B.S., University of the Philippines, Philippine Islands, 1949. Graduate Assistant, Department of Chemistry, and the Industrial Science Research Institute.

Precipitation with acetone of the glucosidase in the enzyme solution that had previously been precipitated with mercuric acetate gave almost quantitative recovery of the enzyme. The great bulk of the glucosidase was precipitated by the 30 to 55 per cent acetone fraction.

Experiments on the effect of pH on the precipitation of the glucosidase by either acetone or ammonium sulfate indicated that the enzyme is least precipitated at pH 5.0 and 5.5 and at pH levels below 4 and above 7. At both pH levels 4.5 and 6.0, the glucosidase appeared to precipitate best with either acetone or ammonium sulfate. There may be two protein fractions possessing the glucosidase activity. It may be possible, however, that at one pH level one of the inactive protein components of the crude enzyme solution is precipitated which then acts as an adsorbent for the glucosidase.

Although starches from different sources have been reported as good adsorbents for alpha-amylase, it was observed that very little purification of the glucosidase from alpha-amylase could be achieved with starch adsorption. Adsorption on activated carbon, celite, and silica gel were employed in the purification. Treatment of the partially purified enzyme solution with from 4 to 6 per cent Norit removed much of the colored materials from the enzyme solution but did not adsorb the glucosidase. Celite and silica gel were observed to remove much of the alpha-amylase.

The purification procedure developed consists of a series of steps involving precipitation with mercuric acetate, acetone, and ammonium sulfate, and removal of much of the unwanted materials by adsorption on activated carbon, celite, and silica gel. The glucosidase activity of the enzyme solution was raised from 15.48 to 1,332.5 units per milliliter. Analysis of the nitrogen activity of the solutions indicated an increase of glucosidase activity per milligram of nitrogen from 11.09 to 362.63 units. More than 50 per cent of the glucosidase activity in the original mold filtrate was lost through the various steps of the procedure. It is obvious that refinement in the various steps of the purification is wanting.

In spite of the low recovery of the glucosidase, it was felt that the enzyme had been sufficiently purified from other carbohydrases, especially from alpha-amylase. Alpha-amylase action on starch is characterized by a rapid breakdown of the starch substrate to small dextrans indicated by the rapid disappearance of the blue color of the starch-iodine complex, accompanied by a slight increase in reducing value. The purified glucosidase from *Aspergillus niger* seems to hydrolyze the starch in a different fashion characterized by the slow disappearance of long chain fragments indicated by the slow disappearance of the blue starch-iodine complex accompanied by a correspondingly large increase in reducing value.

The pH optimum for the mold glucosidase action on both maltose and potato amylose was found to be somewhere between pH 4.0 and pH 4.4.

The enzyme solution that had been heated to 70°C showed no hydrolysis of any of the substrates tested even after an hour of enzyme-substrate reaction. The glucosidase appeared stable after heating at 50°C but showed decreased rates of hydrolysis after heating at 60°C for 15 minutes.

The Michaelis constants for the action of the purified glucosidase upon the linear and branched fractions of corn starch and upon maltose at 30°C were determined by the graphical method of Lineweaver and Burk. The molecular weight for corn amylose was taken as 150,000, and for corn amylopectin as 1,500,000. The Michaelis constants obtained for the three substrates were 0.455 per cent or 1.33×10^{-2} M for maltose, 0.0216 per cent or 1.44×10^{-6} M for corn amylose, and 0.0191 per cent or 1.27×10^{-7} M for corn amylopectin.

Studies on the substrate specificity of the purified mild glucosidase was done by paper chromatography. Methyl alpha-glucoside and beta Schardinger dextrin were not hydrolyzed by the glucosidase. Glucose was the sole hydrolysis product of the hydrolyses of the various substrates that were hydrolyzed by the purified glucosidase. The linear and branched fractions from corn starch, glycogen, a heptasaccharide, gamma Schardinger dextrin, panose, gentiobiose, and maltose were all hydrolyzed to glucose and no other reducing sugar. It appears that the glucosidase of *Aspergillus niger* is not specific for the alpha-1,4 glucosidic linkage in maltose, but is capable of hydrolyzing starches, their components, and their hydrolysis products. The purified glucosidase also showed its ability to hydrolyze both the alpha- and the beta-1,6 glucosidic linkages. It may be possible that other enzymes responsible for some of the hydrolytic actions that were observed have not been entirely removed from the mold enzyme solution.

PHYSIOLOGICAL RESPONSES OF DAIRY CALVES TO INGESTION
OF VARIOUS ANTIBIOTICS AND SURFACE-ACTIVE AGENTS¹HOWARD HENRY VOELKER²

Department of Animal Husbandry

Four experiments were conducted in order to determine the effects of several antibiotics and surface-active agents when fed to dairy calves. In Experiment I, 40 Holstein calves were divided into five groups to determine comparative effects of aureomycin, Terramycin, penicillin, and a surface-active agent (Aerosol C-61) on growth, blood constituents, and fecal characteristics when a milk replacement feeding regime was employed. The antibiotics were fed at the daily rate of 40 mg per calf from 4 to 53 days of age and 80 mg from 53 to 88 days. The surface-active agent was fed at 1 gm per calf daily from 4 to 53 days and 2 gm daily from 53 to 88 days. Highly significant growth stimulation and improved feed efficiency were obtained from aureomycin and Terramycin but not from penicillin or Aerosol C-61. No pronounced antibiotic or detergent effects on incidence and severity of diarrhea were noted, although both were relatively high during 3-5 weeks, inclusive, when the milk replacement (whey product) was fed at the highest levels.

Blood cell counts (erythrocytes, leucocytes, and differential leucocytes), hemoglobin, plasma fat, and fecal pH appeared to be unaffected by antibiotic or detergent feeding although definite age trends in these constituents were noted. The feeding of milk replacement four times daily had no marked influence on these observations or upon incidence of diarrhea and rate of growth.

In Experiment II, 24 calves were involved in a feeding experiment for 11 weeks to determine the response to surface-active agents Aerosol SE, Aerosol AN, TEF-16, and Tide when fed at 1 lb per 1000 lbs of concentrate mixture. No effects of the detergent were noted on growth, feed consumption, plasma fat, diarrhea, or health of calves.

Experiment III was a series of determinations of blood reducing sugars prior to and following oral administration of 50 per cent glucose solutions. In the first phase of this experiment half of the calves were fed 200 mg of aureomycin daily per calf and half served as controls. Varying levels of glucose were employed in the first three trials and calves were fasted for 13 hours prior to glucose feeding in the fourth trial. Blood reducing sugars were higher in aureomycin-fed calves than in control animals subsequent to oral glucose. In further glucose studies in which the calves of Experiment I were employed, 2.25 grams of glucose were administered per pound of body weight. Blood sugar determinations were made at 0, 1, 2, 3, and 6 hours following oral administration. These trials were conducted at 2-3, 5-6, and 10-11 weeks of age. The levels of blood reducing sugars in most instances were highest in calves fed aureomycin or Terramycin, intermediate in the groups fed penicillin or detergent and lowest in the control group. Significant correlations were noted between blood sugar values and 12-week body weight gains. Such a correlation existed even when antibiotic effects were removed and when only the initial blood sugar values (before glucose administration) were employed.

Experiment IV was divided into two phases in order to test the hypothesis that antibiotics function by altering the rate of passage of ingesta through the gastrointestinal tract of dairy calves. Sixteen calves were divided into two comparable groups and rates of passage were determined by marking the feed with carmine. Subsequently, one group was fed 200 mg of aureomycin per calf daily. Upon introduction of aureomycin the mean time for passage through calves was 10.2 hours compared to 7.6 hours previously. Also, the average time for passage of ingesta was significantly longer (2.2 hours) in the aureomycin than in the control group in three trials in which the calves fed aureomycin made average daily body weight gains of 1.87 lbs compared to 1.57 lbs in the control group. In subsequent trials the carmine marker was employed with thirty calves (six calves per group) which were fed either bacitracin, Terramycin, chloromycetin, arsenic acid, or no supplement. None of the treatments altered the rates of passage significantly. In tests run at approximately 1, 3, and 7 weeks of age feed passed more slowly through very young calves than through older animals. Also,

¹Doctoral thesis no. 1643, submitted March 11, 1955. Chairman of Committee, N.L. Jacobson, Department of Animal Husbandry.

²B.S., Iowa State College, Ames, Iowa, 1946. M.S., Kansas State College, Manhattan, Kansas, 1949. Graduate Assistant.

the laxative milk replacement (reconstituted dried whey product) when fed at high levels apparently increased the rate of passage through the calves. The average time for passage through calves with normal feces was 9.1 hours compared to 6.3, 6.5, and 6.0 hours in calves with increasing intensities of diarrhea. The difference in the latter trials compared to the first phase of Experiment IV may have been due in part to the extremely laxative effect of the milk replacement (whey product) so that any antibiotic effects on rate of passage may have been obscured.

PREPARATION OF ZIRCONIUM METAL

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Zirconium metal in the massive form was prepared in a sealed bomb through the use of an exothermic chemical reduction capable of producing sufficient heat to fuse the reaction products. The metallic phase, which was immiscible with the slag phase of the molten reaction products, contained an alloying addition of zinc metal to decrease the melting point and to diminish the interaction with the refractory liner inserted in the bomb. Reductions of potassium fluozirconate, zirconium tetrachloride, and zirconium tetrafluoride were made by the bomb method.

Hafnium-free zirconium was freed from other metallic impurities by crystallizing zirconyl chloride from hydrochloric acid solution. Acetone was used to wash the crystals from the first crystallization. The crystals of zirconyl chloride were dissolved, filtered, and recrystallized from hydrochloric acid solution. Zirconyl chloride from the second crystallization was washed with dilute (1:1) hydrochloric acidsaturated with zirconyl chloride. Contamination of zirconium and zirconium compounds prepared in subsequent processes was reduced with respect to carbon by this recrystallization process.

The addition of 48 per cent hydrofluoric acid to solid zirconyl chloride in fluorothene beakers first formed a solution from which zirconium tetrafluoride monohydrate soon precipitated. The supernatant liquid was decanted and the precipitate was dried in platinum-lined copper trays. Conversion to anhydrous zirconium tetrafluoride was completed by dehydrating the monohydrate in an atmosphere of hydrogen fluoride. The dehydration was made at 500°C in five hours using magnesium-lined Monel metal trays in a reactor constructed of Monel metal. This fluoride product retained the high purity obtained in the zirconyl chloride crystallization.

Zirconium tetrafluoride was also prepared by the action of hydrogen fluoride gas with zirconium tetrachloride at 50°C in graphite trays enclosed in a copper container. Ignition of zirconyl chloride at 250°C gave a material which could be treated with gaseous hydrogen fluoride to furnish zirconium tetrafluoride. Vacuum sublimation at 750-800°C of zirconium tetrafluoride made by these methods was a necessary purification step to remove oxide and other impurities. The sublimed product was not conveniently obtained as pure as zirconium tetrafluoride from the precipitation and dehydration process.

The zirconium compounds were reduced in a steel bomb lined with a sintered dolomitic oxide crucible. Zirconium tetrafluoride was the most satisfactory starting material in the reduction with calcium. The use of iodine with calcium in the reduction charge initiated the reaction between zirconium tetrafluoride and calcium and supplied additional heat to fuse the reaction products. Sulfur could be used in place of iodine, but complete removal of sulfur from the zirconium product was not possible. An alloying addition of zinc metal in the reduction charge decreased the interaction with the refractory liner, since less iodine or sulfur was necessary to fuse the lower melting alloy of zirconium and zinc. The recovery of zirconium metal was more efficient with the use of excess calcium. Ductile zirconium metal was obtained with a reduction charge containing 400 gm of zirconium tetrafluoride, 40 gm of zinc, 64 gm of iodine, and 223 gm of calcium.

¹Doctoral thesis no. 1077, submitted July 14, 1950. Chairman of Committee, Harley A. Wilhelm, Department of Chemistry.

²B.A., Yankton College, Yankton, South Dakota, 1942. Graduate Assistant.

The refractory liner was placed in the steel bomb and this part of the assembly was evacuated and filled with argon three times. The reduction charge was thoroughly mixed and packed in the liner of the bomb. After the bomb was capped the reaction was initiated by heating the bomb assembly in a gas-fired furnace. The regulus recovered was an alloy of zirconium and zinc containing 93-95 per cent of the zirconium. The zirconium content of the alloy was about 85 per cent by weight, although this could be increased by lowering the quantity of zinc included in the reduction charge. Induction heating of the alloy in vacuum removed zinc, calcium, and other volatile impurities. Although some impurities were introduced with the other components of the reduction charge, zirconium metal of high purity was obtained. The practical use of larger bombs with larger charges was demonstrated.

COMPLETELY PRIMARY ALGEBRAS WHICH ARE
DIRECT PRODUCTS MODULO THE RADICAL¹

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The structure theory of linear associative algebras of finite order in many cases is concerned with the decomposition of an algebra into the direct sum of modules. Cohomology theory considers this problem from the point of view of extensions, and has been largely concerned with algebras which satisfy Wedderburn's Principal Theorem, that is, with cleft algebras. This thesis studies uncleft algebras by means of cohomology theory.

Since every uncleft algebra A contains a maximally uncleft algebra A^* (briefly, m.u. algebra A^*) such that $A^*/N^* \cong A/N$, this thesis is restricted to m.u. algebras. Furthermore, an algebra A is m.u. if and only if A/N^2 is m.u. This suggests that A be restricted to a singular extension. The algebra A is also assumed to be completely primary, since the structure theory of all algebras of finite order is to a certain extent determined by completely primary algebras. Most of the results of this thesis concern the completely primary, singular, m.u., "product" L^oM , where L and M are fields over K , and L^oM/N is a field composite, LM .

The principal method used is a projection theory, that is, the dependence of the structure of L^oM upon $H^2(LM, N)$ is shifted to $H^2(LM, LM)$. To do this, it is necessary and sufficient to assume the centrality of the radical of L^oM . This forces almost total commutativity upon L^oM and since the structure theory of commutative algebras is reducible to the case of pure inseparable residue-class fields, this thesis assumes that LM is pure inseparable.

It is shown in this thesis that for an algebra $A = \text{ext}(R, N, g)$ where R is a division algebra, and N is the module extended by the cocycle g , that the projections of g on R are cocycles if and only if N is central. If A is singular, with a central radical, then the projections are non-cobounding if and only if A is m.u. Conversely, to every set of non-cobounding projections there corresponds an m.u. extension of A . The number of linearly independent projections determine the dimension of N .

Using this foundation, the thesis next investigates projections on pure inseparable fields $K(a)$. There is 1-1 correspondence between non-cobounding cocycles of $H^2(K(a), K(a))$ and m.u. singular extensions with 1-dimensional radicals. Secondly, the m.u. extensions of $K(a)$ are singular with 1-dimensional radicals. Finally, there is but one independent projection in $H^2(K(a), K(a))$.

Applying these results to direct products, it is shown that there are three independent non-cobounding cocycles in $H^2(R, R)$ where R is the field $K(a_1) \times K(a_2)$, and that the dimensions of N/N^2 over R is one, two, or three. Finally, the case where $L^oM = L \times M$ is examined. If $M = K(a_1)$ and $L = K(a_2)$, then $L \times M$ is cleft over L if LM over L equals L , while $L \times M$ is m.u. over L if LM over L equals $L(a_1)$. Similar statements apply to $L \times M$ over M .

¹Doctoral thesis no. 1667, submitted June 2, 1955. Chairman of Committee, Bernard Vinograd, Department of Mathematics.

²B.S., St. Ambrose College, Davenport, Iowa, 1949. M.S., Oklahoma A. and M. College, Stillwater, Okla., 1950. Graduate Assistant.

INHERITANCE OF QUANTITATIVE CHARACTERS IN WHEAT¹DALE E. WEIBEL²

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The effectiveness of selection for quantitative characters is dependent upon the heritable variability present in segregating populations. The importance of variation is universally understood by crop breeders, but the degree of heritability of different characters, the rate of improvement that can be expected from selection, and the relative usefulness of various associations among plant and seed characters are not as well established.

Methods of analysis commonly applied to studies of qualitative characters are not applicable for evaluating the inheritance of quantitative characters. Special mathematical techniques adapted to aid in interpreting continuous rather than particulate data have been developed and have received wide usage in recent years. Generally, these methods are designed to evaluate the relative effects of heredity and environment on the expression of plant characters and to establish relationships among characters that might aid the plant breeder in selecting.

The purpose of this study was to evaluate segregating populations of five hard red winter wheat crosses for six plant and seed characters. Data were recorded from spaced-plants of the parents, and of the F_1 and F_2 generations grown in 1951-52 in a randomized complete block design at Manhattan, Kansas. F_3 lines were grown in 10 x 10 triple lattice design during the 1952-53 season along with entries of the parents, and of the F_1 and F_2 generations and backcrosses to both parents. All data were analyzed on an individual plant basis.

The quantitative nature of the characters under study was apparent and verifiable from the smooth frequency distributions. A comparison of F_1 means with mid-parental values indicated dominance or partial dominance of earliness, tallness, many heads, high yield, high kernel weight, and high bushel weight for all crosses. Heterosis was evident in 43 per cent of the F_1 comparisons, 25 per cent of the F_2 comparisons, and 23 per cent of the F_3 comparisons for all characters in all crosses. It was most evident for grain yield and least evident for bushel weight.

Estimates of heritability were calculated 1) by the relative variance of F_2 method, 2) by a comparison of F_2 and reciprocal backcross variances, 3) by regression of F_3 progeny means on F_2 plant values, and 4) by the components of variance of the F_3 analysis of variance. In general, the last method gave the highest estimates while the regression of F_3 progeny means on F_2 plant values gave the lowest estimates. The average of 25 estimates of heritability for each character over all crosses provided the following values: date first bloom, 36.0 per cent; plant height, 50.2 per cent; kernel weight, 45.2 per cent; and bushel weight, 49.5 per cent. It was concluded that individual plant selection in F_2 for these characters should be effective and satisfactory for practical breeding purposes although it might not be equally effective for all crosses. Heritability values obtained for number of heads and grain yield were only 1.3 and 7.7 per cent, respectively. For these characters it was concluded that individual plant selection in F_2 would not be effective and, therefore, that the rate of improvement could not be expected to exceed that from random selections.

Phenotypic, environmental, and genotypic correlation coefficients among characters were calculated 1) from P_1 , P_2 , F_1 , and F_2 data by covariance analyses and 2) from F_2 and F_3 data by regression analyses. The phenotypic correlations obtained in F_2 and F_3 generations showed that early blooming was correlated with short plants in some crosses and with tall plants in other crosses. Early blooming was correlated with many heads, high grain yield, high kernel weight, and high bushel weight. It appeared that the selection of early maturing F_2 plants would be effective in obtaining plants with high kernel weight and high bushel weight, but that only a random sample would be obtained for number of heads and grain yield in view of the low heritability of these characters.

Tall plants were strongly correlated with many heads and high grain yield, but due to the low heritability of the latter characters it appeared that short, high yielding

¹Doctoral thesis no. 1629, submitted January 6, 1955. Chairman of Committee, R.E. Atkins, Department of Agronomy.

²B.Sc., University of Nebraska, Lincoln, Nebr., 1942. M.Sc., Ibid., 1947.

selections could be obtained. Tall plants were highly correlated with high kernel weight and high bushel weight in certain crosses indicating that difficulty might be expected in the selection of short, high kernel weight, and high bushel weight plants.

The highest correlations obtained were between number of heads and grain yield, but since both characters exhibited very low heritability values the association probably is of limited value as an aid to selection in the F_2 generation. Similarly, associations of numbers of heads with kernel weight and with bushel weight were not considered to be of practical importance.

High grain yield was correlated with high kernel weight and high bushel weight, but due to the low heritability of grain yield it was suggested that selection for kernel weight or bushel weight be practiced in F_2 with testing for yield to follow in later generations. The data showed that kernel weight and bushel weight were very strongly correlated, and thus selection for high kernel weight in F_2 should also be effective in obtaining plants with high bushel weight.

Environmental correlations involving number of heads or grain yield generally were larger, while genetic correlations were smaller than phenotypic correlations. The expression of these characters was greatly influenced by environmental factors and heritable variation was low. The remaining characters had higher heritabilities and generally the environmental correlations were smaller while genetic correlations were larger than phenotypic correlations.

CAUSTIC TREATMENT OF ZIRCON SAND¹

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Recent interest in zirconium and zirconium compounds has led to the development of better methods for opening up zirconium ores, particularly the principal domestic ore, zircon. In the caustic treatment of zircon, approximately equal weights of caustic soda and zircon are reacted at a furnace temperature of 1050°F to form a fragile, granular solid. This solid is then leached with water to remove the water-soluble sodium silicates, and to produce an impure hydrous zirconium oxide which is easily converted into a variety of zirconium compounds, such as the oxychloride, fluoride, sulfate, nitrate, hydroxide, and oxide.

The purpose of this investigation was threefold: 1) to study the batch caustic treatment of zircon on a pilot plant scale, 2) to develop a continuous method for carrying out the caustic treatment of zircon, and 3) to study the water leaching of the reaction product. In the study of the batch caustic treatment, particular emphasis was placed on the evaluation of the caustic-to-zircon ratio, the batch heating cycle, the charge size and the effect of zircon particle size as process variables.

The caustic-to-zircon weight ratio was found to be a significant process variable. As the caustic-to-zircon ratio was increased, the conversion of zircon increased, but the utilization of the caustic soda decreased. An economic balance, based on pilot plant data, indicated an optimum caustic-to-zircon weight ratio of 1.1:1, when the unreacted zircon was not recovered.

The heating cycle also affected the conversion of zircon in batch caustic treatments. It was found that the time between the charging of the reactants to the furnace and the formation of a solid reaction product could be varied considerably with little effect on conversion. However, excessively long heating times led to the formation of a hard, dense reaction product which was difficult to remove from the reactor. The long heating time also caused a decrease in the zircon conversion. Heating the reaction product after the formation of a porous, friable solid resulted in some improvement in the zircon conversion. However, in view of the time required to produce a small increase in conversion, such heating was not regarded as economically feasible.

Of lesser significance were the effects of charge size and zircon particle size.

¹Doctoral thesis no. 1592, submitted August 13, 1954. Chairman of Committee, G.H. Beyer, Department of Chemical Engineering.

²B.S., Iowa State College, Ames, Iowa, 1948. Research Assistant, Institute for Atomic Research.

Over a range of charge sizes from 21 to 72 pounds of zircon, no trend indicating an effect due to charge size was found. Little improvement in conversion was obtained when the zircon was ground. In view of the hardness of zircon and the attendant high grinding costs, the use of ground zircon was not recommended.

A simple, continuous reactor for the caustic treatment of zircon was developed. The reactor was constructed of a short length of 2-inch pipe, closed at one end and slotted on top to permit the passage of anchor-shaped drags. Zircon was fed into a pool of molten caustic at the back of the inclined reactor, where the drags picked up the reactants, slowly moved them through the hot reactor and finally discharged the reaction product. Zircon conversion of about 85 per cent was obtained, but the utilization of the caustic soda was significantly poorer than in the batch reactor.

Laboratory studies indicated that water leaching of the reaction product, using either simple multiple-contact or continuous countercurrent decantation, would be satisfactory. Leached reaction product, principally hydrous zirconium oxide, has been successfully used for the production of a variety of zirconium compounds.

A cost analysis of the batch caustic treatment of zircon was made, based on a projected plant capacity of 1000 pounds per day of zirconium in the leached reaction product. It was estimated that hydrous zirconium containing about 60 per cent ZrO_2 on a dry basis would cost approximately 57¢ per pound of contained zirconium.

The caustic treatment of zircon proved to be a simple and convenient method of converting zircon sand into a granular product, which, after leaching with water, formed a suitable raw material for further processing to zirconium compounds. The low caustic-to-zircon ratio and the simple equipment required for decomposing the zircon without previous grinding make this process attractive.

ACCURACY OF PARTIAL TRAPNEST RECORDS AS A BASIS FOR SELECTING WHITE LEGHORN HENS FOR EGG PRODUCTION¹

JOHN D. WHEAT²

Departments of Animal Husbandry and of Genetics

The objectives of this study were:

1. To evaluate the accuracy of trapnesting 1, 2, 3, . . . n days per week in estimating the annual records and the breeding values of White Leghorn hens,
2. To determine the relation between the rate of lay for specific periods of the year and the annual rate,
3. To estimate the heritability of annual egg production.

The data were from the Kimber Poultry Breeding Farm at Niles, California, and included records for the years 1934-1940. They consisted of the daily, monthly, and annual production records for 403 hens and the annual records for their first five daughters which lived at least 30 days beyond the 365-day laying period. The breeding plan was to avoid the mating of brothers and sisters or other close relatives. The 2, 015 daughters were sired by 105 males. The dams had been intensely selected on the basis of their production records as well as on family records and other economic characteristics, such as egg quality, egg weight, fertility, and viability.

Repeatability of daily egg production was the only biological factor which affected the accuracy of partial trapnesting. The accuracy of partial records in estimating annual production and the breeding value of the hens was .85, .93, .96, .98, .99, and .99 of that for complete records when the number of trapnesting days per week was one, two, three, four, five, and six days, respectively.

The increases in flock size required to offset the errors caused by partial trapping were 60, 23, 9, 6, 4, and 2 per cent when the records for one, two, three, four, five, and six days per week were used to estimate the annual record.

¹Doctoral thesis no. 1615, submitted December 8, 1954. Chairman of Committee, L.N. Hazel, Department of Animal Husbandry, and John W. Gowen, Department of Genetics.

²B.S., Texas A. and M. College, College Station, Texas, 1942. M.S., Ibid., 1951. Graduate Assistant.

The first production year for the dams was divided into four periods; the first extended from the date of the first egg to November 30 with an average length of 83 days; the second extended from December 1 to March 31 and averaged 121 days; the third consisted of April, May, June, and July and averaged 122 days, while the fourth averaged 39 days and extended from August 1 to the end of the first production year. The correlations between the rates of lay for the four periods and the annual rate were .33, .49, .86, and .46, respectively. The regression of the annual rate on rates for the four periods was .51, .56, .46, and .16.

The heritability estimate for annual egg production obtained by doubling the intra-sire regression of daughter on dam was .123. The estimate derived by multiplying the paternal half sib correlation by four was .230, and the estimate obtained by doubling the full sib correlation was .183.

When heritability of individual differences in annual production is .123 and .230, the heritability of differences in family averages is .269 and .504, when family size is five.

If selection of mature hens were to be made on the basis of individual performance and family merit when heritability of individual differences is considered to be .123 and .230, an increase of one egg in the five daughters' average record should receive 1.32 and 1.15 times as much emphasis as an increase on one egg in the dam's own record.

Expected genetic progress from one generation of selection by truncation, when heritability is .183 and when 20 per cent of the females are selected, is 8.33 eggs when complete records are used. The expected annual (1.67 years per generation) gain from complete records is 4.99 eggs. When the annual production is based on the records for one to six days per week, the expected genetic gains per generation range from 7.08 to 8.26 eggs, and the expected annual gains range from 4.24 to 4.95 eggs.

THE USE OF CHELATING AGENTS IN THE SEPARATION OF THE RARE EARTH ELEMENTS BY ION-EXCHANGE METHODS¹

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The research described in this thesis was undertaken in order to accomplish two main objectives. The first was to measure the stability of the complexes formed by each of the trivalent rare earth cations with ethylenediaminetetraacetic acid, abbreviated EDTA, and with N-hydroxyethylethylenediaminetriacetic acid, abbreviated HEDTA. The second objective was to find methods for using the two chelating agents in conjunction with an ion-exchange resin for separating rare earths.

The stability constants of the complexes formed between the rare earth metal ions and the anion of EDTA have been measured at a temperature of 20°C and an ionic strength of 0.10 by two independent methods. The two methods are shown to supplement each other, one being more accurate for the lighter rare earths and the second method more accurate for the heavy rare earths.

In the first method, the rare earth-EDTA stability constants were calculated from measurements of the equilibrium constants of reactions involving competition between EDTA and a polyamine chelating agent, triaminotriethylamine, for the rare earth ions and copper ions. The equilibrium constants were calculated from pH measurements upon the various reaction mixtures.

The second method is based upon the fact that it is possible to measure the concentration of free uncomplexed copper II ions in the presence of the copper complex, CuY^{-2} , by polarographic means. The rare earth-EDTA stability constants were determined by measuring the amounts of copper II ions liberated when equal molar amounts of the copper-EDTA complex and a rare earth salt are mixed together.

The acid association constants of HEDTA were calculated from pH titration curves

¹Doctoral thesis no. 1656, submitted May 24, 1955. Chairman of Committee, Frank H. Spedding, Department of Chemistry.

²B.S., Brigham Young University, Provo, Utah, 1950. Research Assistant, Institute for Atomic Research.

obtained by potentiometrically titrating the acid with standard KOH at 25°C and an ionic strength of 0.10.

The stability constants of the complexes formed between the rare earths and the anion of HEDTA were measured at a temperature of 25°C and an ionic strength of 0.10. The methods used were the same as those described for measuring the rare earth-EDTA stability constants. In this case, the potentiometric method is shown to give more accurate constants.

A rapid method for separating the individual rare earths into enriched fractions has been developed. The process consists of complexing part of the rare earths in a mixture--those rare earths form the more stable complexes--with EDTA and separating the complexed rare earth ions from the uncomplexed ions by passing the mixture through an ion-exchange column in the ammonium cycle. The complexed ions pass through the resin bed, but the uncomplexed ions are adsorbed.

A method has been found for separating pure rare earths in macro quantities from rare earth mixtures. The method consists of eluting a band of mixed rare earths, adsorbed on a cation-exchange resin, through a second cation-exchange resin bed in the copper II or iron III state. Copper was found to be far superior to iron. The eluant consists of an ammonia-buffered solution of EDTA.

The elution of a mixture of all of the rare earths down an ion-exchange bed with an ammonia-buffered solution of HEDTA indicated that this chelating agent is not as effective for separating the heavy rare earths as the EDTA-copper II system under the conditions tested.

WALLEYE, STIZOSTEDION-VITREUM (MITCHILL),
POPULATION OF CLEAR LAKE, IOWA¹

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A total of 2,232 walleyes were tagged at Clear Lake, Iowa, in 1952 and 1953, to obtain population estimates and estimates of fishing mortality. Since good mixing of tagged fish during tagging was demonstrated, the number of walleyes on the spawning grounds could be estimated as 12,776 in 1952 and 16,311 in 1953. An estimated 12,119 of the 1953 spawning population were males.

From samples taken after spawning, the number of walleyes over 16 inches in total length was estimated as 6,030 in 1952 and 4,872 in 1953. Although walleyes under 16 inches in total length were apparently the most abundant fish in the population, few of them were tagged, probably because they were not sexually mature and would therefore not appear on the spawning grounds where the tagging was done. Because the two types of gill nets used in sampling selected different sizes of walleyes and because the ratios of tagged fish in the size groups differed, it was necessary to estimate the numbers by size groups for a combined estimate of 30,822 walleyes over 12 inches in total length in 1953 (8.46 per acre). This estimate was derived after correcting for loss of tags which was estimated as 40 per cent from 1952 to 1953.

Scales for the age and growth study were selected from each year's sample by a method of stratified subsampling. From these data it appeared that the 1946, 1947, and 1950 year classes were more successful than others.

Since no differences were found between the regressions of body length on scale lengths of three year classes nor of three years of capture, the regression, total length = 3.2595 + 1.3101 scale radius (x 50), based on all 1,209 scales was used in estimating past growth histories. The 1950 year class, which was more abundant than the others, grew more slowly in its first and second years than the other year classes. Growth of all year classes was apparently low in 1950, due perhaps to cold summer weather. The 2-inch mesh gill nets apparently selected larger, faster-growing walleyes than the experimental gill nets.

¹Doctoral thesis no. 1630, submitted January 7, 1955. Chairman of Committee, Kenneth Carlander, Department of Zoology and Entomology.

²B. A., University of Utah, Salt Lake City, Utah, 1949. M.S., *Ibid.*, 1951. Graduate Assistant, Industrial Science Research Institute.

Fishing mortality was estimated from tag returns from anglers at 15.7 per cent in 1952 and 6.3 per cent in 1953. Estimates of natural mortality varied from 11.2 to 40.2 per cent.

The State Fish Hatchery stocked no fry in 1949, 1951, and 1953 to permit a test of the effectiveness of fry stocking. Fewer fingerlings were caught per seine haul in these three years than in the years of fry stocking and the most abundant year classes of 1946, 1947, and 1950 came from years of hatchery operation.

The sex ratio on the spawning grounds was 2:1 in favor of males in 1952 and 9:1 in 1953, but the ratio in the population at large was probably close to 1:1.

LINEAR MODELS AND RANDOMIZED EXPERIMENTS¹

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This thesis is concerned with the derivation and interpretation of linear statistical models for randomized experiments and with their application and use in the analysis of such experiments. The central features of both the underlying philosophy and methodological detail are the concepts of "true response," "experimental unit," and the use of randomization in the design and procedure.

The first part of the thesis gives some introductory or expository discussions on experimental error, randomization, classification of types of models, the analysis of variance, and the relation of some aspects of this thesis to other published and unpublished work.

The second part of the thesis details results from the study of the standard statistical experimental designs, namely the completely randomized, randomized block, Latin square, and split plot designs, under quite general experimental conditions. Linear statistical models, whose components depend on parameters defined on the population of "true" responses and on certain "dummy" random variables which reflect the (randomized) experimental design and procedure, are derived for each of these designs under the general experimental conditions. These models, which are definitional in the sense that they do not depend on notions of causality, mechanism or functional relation, are employed in the study of the analysis of variance and of various estimation questions. In particular, general results on expectations of analysis of variance mean squares are given, which are valid for so-called fixed, mixed, and random model situations as special cases as well as for all intermediates. Interactions of treatments with experimental units are found to occasion a "bias" in the analysis of variance in the sense that one cannot, in general, obtain from the mean squares unbiased estimates of components of variation. The estimable (under all conditions) functions in the analysis of variance are found to have well-determined and defined structures, and considerable attention is given to describing and detailing these structures. The pattern of expected mean squares in terms of these estimable functions is shown to be quite simple and this pattern is of very considerable value in unification, simplification, and extension of the results. Considerable discussion is given of the general implicit and explicit definitions of the estimable functions in terms of the components of variation and population sizes, and of the pattern of expected mean squares for general situations in terms of these estimable functions. Either as part of overall discussions or in connection with the study of particular situations, attention is given to: general expected mean squares for cases of unequal and proportional numbers in the cells; alternative analyses of variance for certain unbalanced experiments; the dependence of reasonable assumptions concerning properties of and relationships among parameters of the conceptual population on the intent of the experimental design; questions concerning estimates of effects, of errors, and of components of variation; the selection of appropriate test criteria for various null hypotheses; the

¹Doctoral thesis no. 1675, submitted June 3, 1955. Chairman of Committee, Oscar Kempthorne, Department of Statistics.

²B.Eng., McGill University, Montreal, Canada, 1945. M.S., Iowa State College, Ames, Iowa, 1953. Instructor, Department of Statistics. Associate, Industrial Science Research Institute.

general effects of nonadditivities; the accomplishments of randomization; the dependence of "error terms" on the experimental procedure. The basic assumptions underlying the development are summarized, and their weakening discussed, in a section under general discussions.

In the third part of the thesis a brief discussion is given of the notion of functional structure and the problem of elucidation of functional structure by statistical techniques. The literature of relevance on this matter is reviewed in the context. The idea that the underlying functional structure determines certain properties of and relationships among components of the definitional (derived) linear statistical model is put forth. This idea is applied in the derivation of an approximate test for a multiplicative functional structure. A rough visual method for the evaluation of the adequacy of the postulated function structure is described. A more objective basis for evaluation and for the interval estimation of an unknown parameter of the postulated structure is developed, based on a number of statistical assumptions and distributional approximations.

HOST REACTION TO *HELMINTHOSPORIUM VICTORIAE* AND RELATED SPECIES¹

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A *Helminthosporium* culm rot fungus attacking oats in the southern United States has modes of parasitizing similar to *H. victoriae* and *H. sativum*. The possibility of a new *Helminthosporium* species developing on southern oat crops, and the relationship it might have to *H. victoriae* and *H. sativum* have led to this study.

References in the literature to this culm rot fungus suggest it resembles *H. sativum* more closely than *H. victoriae*. An outstanding feature of the culm rot malady is the blighting of oat varieties resistant to *H. victoriae*.

From 75 *Helminthosporium* isolates obtained from naturally infected oats and barley, ten representative, sporulating cultures were selected for comparison: isolates 1, 2, 3, and 4 exemplified *H. victoriae*; isolates 5, 6, 7, and 8 exemplified the culm rot organisms; and isolates 9 and 10 exemplified *H. sativum*.

In the experimental results the ten *Helminthosporium* isolates under scrutiny generally defined themselves into two groups. Isolates 1, 2, 3, and 4 formed the *H. victoriae* group, while isolates 5, 6, 8, and 8 (selected as being culm rot organisms) displayed enough characteristics in common with *H. sativum* isolates 9 and 10 to comprise a group appearing to be *H. sativum*.

Morphological comparisons of conidial characteristics supported the *H. victoriae* and *H. sativum* grouping of the isolates. Though some differences existed in conidia within these two groups, these variations seemed more the rule than the exception within species. Diagnostic characteristics which might separate the culm rot isolates from *H. sativum* were not observed.

Conidia of isolates 1, 2, 3, and 4 measured 40.8 to 47.6 by 13.6 to 17.0 , with mode of 5 septa, were light olive green in color, and had thin cell walls. Conidia of isolates 5 and 6 measured 57.8 to 68.0 by 17.0 to 23.8 , with mode of 6 septa; and conidia of isolates 9 and 10 were 74.8 to 78.2 by 20.4 to 23.8 , with modes of 6 and 7 septa. Conidia of isolates 5, 6, 9, and 10 were dark olive to brown in color and had thick cell walls. (Isolates 7 and 8 did not produce conidia in culture.)

Physiological tests, generally showed similar patterns of response for all ten *Helminthosporium* isolates. Close comparison of the results of the physiological experiments indicated that isolates within species, as well as isolates among closely related species, vary in requirements for normal growth.

Variance analysis of temperature effects on mycelial growth revealed greater differential among isolates of the *H. victoriae* grouping than the *H. sativum* grouping, with highly significant difference between the two groups.

¹Doctoral thesis no. 1655, submitted May 21, 1955. Chairman of Committee, I. J. Johnson, Department of Agronomy, and H. C. Murphy, Department of Botany and Plant Pathology.

²B.S., Colorado State College, Greeley, Colo., 1947. M.S., Ibid., 1949. Graduate Assistant, Agricultural Experiment Station.

Toxicity investigations illustrated that metabolic products of the H. victoriae group wilted Victoria oats at very low concentrations. This result agrees with reports in the literature of the importance of toxic action of H. victoriae in the process of parasitizing. Isolates in the H. sativum grouping produced metabolic products that required high concentrations to wilt Cherokee and Victoria oat seedlings.

In the pathogenicity investigations special results occurred which were paradoxical to the host specificity established in the literature for H. victoriae and H. sativum. All isolates of the H. victoriae group killed Victoria oats, but some isolates of this group also killed Southland oats and Vantage barley. Peatland barley showed slight invasion by some H. victoriae isolates. Southland oats, Vantage and Peatland barley were killed by most isolates of the group considered to be H. sativum. Cherokee oats were highly resistant to all ten Helminthosporium isolates. These results seem to exemplify the variation that can occur (as frequently as uniformity) in work with fungi; explaining in part the conflicting data reported by different investigators.

To establish sources of resistance, over 4,000 oat varieties and selections were inoculated with Helminthosporium culm rot and H. victoriae. Results pertaining to specific varieties are on record at Iowa State College in the Agronomy Department, Farm Crops Section. Incidental to this large scale inoculation of oats it was discovered that nine oat varieties, with C.I. numbers predating the introduction of Victoria oats (C.I. 2401) into this country, were susceptible to H. victoriae and displayed the Victoria-type resistance to crown rust.

Future studies concerning the relationship of the Helminthosporium culm rot organisms to H. victoriae and H. sativum should include a wider selection of isolates representing each group; thus providing a more panoramic viewpoint from which to base a conclusion, until such time as the fungi are stimulated to their perfect stages for positive identification.

ACTION OF MANGANESE AND RHENIUM COMPOUNDS IN THE DECOMPOSITION OF POTASSIUM CHLORATE¹

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Department of Chemistry

The general purpose of this study was to elucidate more fully the catalytic action of manganese compounds on the decomposition of potassium chlorate. Specifically, the problem involved:

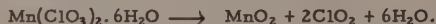
1. The use of radiochlorine³⁶ tracer to determine which of two proposed mechanisms for the decomposition of KClO_3 is possible.
2. The preparation of manganese chlorate with a view toward determining whether or not its formation is a part of the catalysis when KClO_3 is decomposed with manganese catalysts.
3. The description of the catalytic activity of some rhenium compounds on the decomposition of KClO_3 , and the relationship between the activity of rhenium catalysts and manganese catalysts.
4. The analyses of residues from catalytic decomposition of KClO_3 to determine the fate of the manganese and rhenium catalysts.
5. The determination of activation energies for the various reactions by kinetic studies.
6. The use of oxygen¹⁸ isotope tracer to check the results of the above experiments.

¹Doctoral thesis no. 1588, submitted July 20, 1954. Chairman of Committee, F. E. Brown, Department of Chemistry.

²B.S., Central College, Pella, Iowa, 1947. M.S., Iowa State College, Ames, 1950. Graduate Assistant, Department of Chemistry and Industrial Science Research Institute.

A mixture of ordinary KClO_3 and KCl enriched with radioactive Cl^{36} was decomposed under conditions in which a chloride-chlorate-perchlorate residue was produced. Negligible activity was found in the chlorate and perchlorate. This does not support a suggestion by Glasner and Weidenfeld (J. Am. Chem. Soc. 74:2464, 1952) that perchlorate forms by addition of oxygen to chloride. Results also showed that chloride undergoes no appreciable isotopic exchange with chloride or perchlorate at 510°C .

Manganese (II) chlorate was prepared by reacting equivalent quantities of MnSO_4 and $\text{Ba}(\text{ClO}_3)_2$ and removing the insoluble BaSO_4 . Water was removed from a frozen solution in one arm of a U-tube by immersing the other arm in a liquid air bath. The product was analyzed by allowing it to warm to its decomposition point and collecting the products of decomposition. The product was a pink solid with the formula, $\text{Mn}(\text{ClO}_3)_2 \cdot 6\text{H}_2\text{O}$. It melted at -18° to -15°C and decomposed at 6° to 10°C . The decomposition corresponds to the following equation:



The fact that ClO_2 is a product of decomposition, rather than O_2 , decreases the probability of this compound being involved in the catalytic action of manganese compounds on the decomposition of KClO_3 .

Eight manganese catalysts (Mn , MnO , Mn_3O_4 , Mn_2O_3 , Baker and Adamson MnO_2 , Fisher Scientific Co. MnO_2 , freshly prepared MnO_2 , and KMnO_4) were used to decompose KClO_3 at two or more temperatures (366°C , 340°C , and other temperatures). Analyses of residues from the reactions revealed that the manganese existed in a mixture of oxidation states, as an oxide with oxidation states +3 to +4, and as a form extractable in water as permanganate. All manganese catalysts exhibited a continued type of catalytic action.

Five rhenium catalysts (Re , ReO_2 , ReO_3 , Re_2O_7 , and KReO_4) were used to decompose KClO_3 at two temperatures (366°C and 340°C). Analyses of the residues from the reactions revealed that all the rhenium was converted to perrhenate in each case. The reactions liberated oxygen rapidly for only a short time. This indicated that catalytic action occurred only while the rhenium was undergoing oxidation.

The rates of oxygen evolution from the above reactions were measured by an automatic recording balance built for this study. The device automatically plots against time any changes in weight of a reaction tube suspended from one arm of the balance beam into a furnace below the balance. A mirror on the balance beam deflects a ray of light to one or the other of a pair of photocells. The photocell response is amplified and fed to a galvanometer in the recorder. Deflections of the galvanometer control a motor driven pen. As weight changes, the balance is automatically brought back to the null position by a controlled current flowing in coils around a magnet suspended from the other balance arm. This current in the coil is controlled by a potentiometer fastened directly to the pen mechanism of the recorder. A damping circuit is incorporated in the electronic control unit to prevent overswing of the balance. The balance can plot small changes in weight with an uncertainty of only ± 0.2 mg over extended periods of time.

From rates of the KClO_3 decompositions as recorded by the automatic balance, catalytic activities were compared and apparent activation energies for the reactions were computed. The first order rate law held over the first parts of the reactions only. The activation energy of pure KClO_3 (54 kcal. per mole) agreed with that in the literature. Apparent activation energies for decompositions with manganese and rhenium catalysts were lowest for the catalysts with manganese or rhenium in an intermediate oxidation state. The reactions with rhenium catalysts generally had much lower activation energies than reactions with manganese catalysts.

Permanganate decomposes at 240°C , whereas perrhenate is stable at above 1370°C . Manganese catalysts exhibited a continued type of catalytic activity while rhenium catalysts were active only while being oxidized to perrhenate. These facts lead to the conclusion that the catalytic action occurs during a change in oxidation state of the manganese or rhenium. The continued catalysis by manganese can be explained by the instability of permanganate at temperatures of the reactions. Permanganate decomposes as it is formed, and a succession of oxidations and reductions occur, thus continuing the chlorate decomposition. Not all of the manganese was active during the decomposition of KClO_3 with manganese catalysts as was pointed out by the fact that most active catalysts did not cause reactions with the lowest activation energies.

The above conclusions were checked by use of oxygen¹⁸ isotopic tracer techniques. Potassium chlorate was decomposed with manganese oxide enriched in oxygen¹⁸. The

oxygen, liberated during the first and last parts of the decomposition, contained oxygen¹⁸. The catalyst residue still contained some oxygen¹⁸. These results agree with the conclusions from the other experiments; namely, that the catalytic decomposition of $KClO_3$ with manganese catalysts involves a succession of oxidations and reductions of those manganese atoms involved in the catalysis.

THE BOMBAY TENANCY AND AGRICULTURAL LANDS ACT AS A MEANS FOR AGRARIAN REFORM¹

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The Bombay Tenancy and Agricultural Lands Act of 1948 is one of the basic land reform enactments in India. As one of the means by which the Bombay government hoped to alleviate the problems of economic underdevelopment, the effectiveness of the Bombay Act is important not only to Bombay but to the entire Indian Union, many states of which have used the Act as a model.

The tenancy situation as it existed in 1948 was an outgrowth of many technical, economic and institutional factors. Basic to problems in tenancy were the more general problems of low income due largely to heavy population pressure and low rate of capital accumulation. The relatively low productivity of the labor factor resulted in wide disparities in income between owners of scarce capital and land and those who contributed only labor in leasing agreements. Low income cultivators regressed on the agricultural ladder because of debts incurred to cover cost of production and consumption. Holdings and tenancies became smaller through subdivision and subletting. Where there was severe competition and rapid turnover of tenants, uncertainty tended to cause tenants to refrain from making resource inputs in uses where the benefits matured over a long period. Factor limitations also reduced inputs for improvements. Custom and tradition were obstacles to the adoption of new techniques as well as to flexibility in leasing arrangements.

With a recognition of its place in the over-all reform program the Bombay Tenancy Act was analyzed in terms of its objectives of economic development and equitability in the income distribution. The purposes of the study were to, 1) test conceptually the principal provisions of the Act in terms of their ability to satisfy the conditions necessary for a movement toward specified objectives, 2) provide hypotheses concerning the effect of the Act with respect to its objectives which might be tested empirically as information becomes available, and 3) suggest improvements in the Act.

The procedure followed in the analysis of the provisions of the Act was first to specify the criteria or conditions that would be required of the provisions of the Act in order to permit a movement toward the objective. The objective of economic development is dependent upon efficiency in production and growth. The phases of production efficiency with which the Tenancy Act is concerned are factor payments, uncertainty, and mobility. Two necessary conditions of growth are capital accumulation and the adoption of innovations.

Another explicit objective is concerned with the equitable distribution of income, the standard of an equitable distribution being a movement toward equality.

The provisions of the Act analyzed were those dealing with security of tenure, rent regulation, prohibition on subletting, transfer restrictions, state management, and compensation.

On the basis of the ability of the provisions to satisfy the conditions for efficiency, growth and distributive equitability, it appeared possible to make certain tentative recommendations when the change met the conditions for a movement toward one objective without a diminution of another objective.

The rent regulation was seen to have two effects, 1) on the allocation of resources, and 2) on the distribution of income. It was suggested that the distribution of income

¹ Doctoral thesis no. 1654, submitted May 18, 1955. Chairman of Committee, John F. Timmons, Department of Economics and Sociology.

² B.Sc., University of North Dakota, Grand Forks, N. Dak., 1949. M.S., Iowa State College, Ames, 1951. Graduate Assistant.

may be effected by changing the ownership of resources or the payment to factors. But altering the payments to factors affects the allocation of resources unfavorably. Therefore, it appeared that the distribution of income might be adjusted with less undesirable effects to efficiency if ownership of the resources were transferred rather than a change made in the payment to the factors.

The rent regulation adjusts the distribution of income only between the landlord and tenant classes, and not between income classes as such. Therefore, the rent regulation will induce a movement toward a more equal distribution of income among individuals only insofar as landlords are in a higher income position than tenants. Although the average income of landlords is probably higher than the average income of tenants, there was some evidence that their income distributions overlap. For the foregoing reasons, it was recommended that rent regulation be abandoned except to offset the effects of imperfect competition in lease bargaining.

If a better distribution of income is desired, it may be further recommended that it be effected either through the transfer of resources or direct transfer of income. The ownership of some resources, e.g., labor, cannot be easily transferred. In such cases direct transfer of income may be made, e.g., through the income tax. The transfer of resources may have an unfavorable effect on expectations if carried out too often, and therefore should be utilized as a once-for-all measure.

It appears that the usefulness which the distinction between ordinary and protected tenant may have had at the time of the passage of the Act no longer exists. It was, therefore, recommended that only one class of tenant be used in the Act. This being done, all tenants could be entitled to a compensation provision which now applied only to protected tenants. With all tenants assured of compensation of all inputs the value of which had not expired at the time of tenancy termination, tenants would be provided with an incentive to make inputs the benefits of which mature over a long period. This would also eliminate the need for the fixed-tenure provision and would reduce the obstacle to resource transfers.

It was recommended that the provision which prevents the subdivision and subletting of land be strengthened to make it effective. To do this it was recommended that the proviso of the 1952 Amendment be so changed as to prevent the partition and subdivision of the leased land at the time of the death of the tenant.

FIELD STUDIES ON EIMERIA SPECIES IN CHICKENS ON TWO CENTRAL IOWA FARMS¹

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An investigation was initiated in 1952 to make a thorough study of the epidemiological aspects of *Eimeriae* occurring in chickens on a central Iowa farm, the Steele farm. In 1953 the Parks farm was added. Two breeds of chickens were used each year. In 1952 they were Austra Whites and New Hampshire Reds, while in 1953 White Leghorns were used instead of Austra Whites. Groups of from two to nine chickens were collected at random on the farms at one- or two-week intervals during the outdoor poultry season, commencing shortly after the chicks were hatched. Species determinations were made on oocysts observed in fecal examinations during the first five days after the birds were collected.

Six of the eight species of *Eimeria* known to occur in chickens were found in birds from the Steele farm during both years of the study, these being *E. acervulina*, *E. brunetti*, *E. maxima*, *E. mitis*, *E. necatrix*, and *E. tenella*. Five of the above six species were also found on the Parks farm, the one absent being *E. necatrix*.

Although the same six species of *Eimeria* were found during both years of the Steele farm studies, marked differences existed in the infection pattern. The most prominent species during 1952 was the innocuous *E. mitis*, which appeared in 11 of the 13 groups

¹Doctoral thesis no. 1639, submitted March 8, 1955. Chairman of Committee, Elery R. Becker, Department of Zoology and Entomology.

²B.S., Minnesota Teachers College, Mankato, Minn., 1947. M.S., Iowa State College, Ames, 1952. Graduate Assistant, Industrial Science Research Institute.

collected. E. tenella and E. maxima were also relatively abundant. Although E. tenella was detected in only one chicken taken before August 18, it was found in about 50 per cent of the remaining test birds. One case of clinical coccidiosis due to E. tenella was found on August 25. E. maxima was abundant late in July and during August. Only scattered infections with E. acervulina, E. brunetti, and E. necatrix were detected.

During the 1953 Steele farm study, E. acervulina became the most abundant species, while E. mitis was not found after the group of July 6. E. tenella was prominent much earlier in the study than in 1952, being especially abundant in June. E. brunetti was abundant in June and early July. Only scattered infections of all species were found after July 6.

The chickens on the Parks farm were of late-spring hatch as contrasted to those on the Steele farm which were of mid-spring hatch. Four species were found in the first group of chickens obtained from the Parks farm on June 29, 17 days after hatching. Since the chickens had been confined to a new chicken house prior to that time, all these initial infections were the result of contamination brought in by the attendant. A severe outbreak of coccidiosis due to E. tenella was apparent when seven of the eight chickens obtained from the Parks farm during the week of July 13 had clinical cecal coccidiosis. The peak of incidence and intensity of all five species encountered on the Parks farm was reached early in the study as only scattered infections were noted after mid-July.

Although E. tenella was the only species causing clinical coccidiosis in the birds examined during the three studies, the potential existed for severe outbreaks with E. tenella, as well as for most of the other species found on the two farms if predisposing factors were suitable for a rapid build-up of infective oocysts before protective immunity had developed in the birds comprising the flocks.

Development of immunity was determined by administration of challenging dosages of oocysts of selected species. The species used in 1952 were E. tenella, E. brunetti, and E. necatrix. E. acervulina replaced E. necatrix as a test organism in 1953. Development of immunity to E. tenella and E. acervulina closely paralleled outbreaks with these species in the field. More than one light infection appeared to be necessary for development of immunity to E. tenella. Complete immunity was present in some birds four weeks after initial outbreaks with this species. Immunity to E. acervulina seemed to develop at a somewhat faster rate than for E. tenella, but a smaller percentage of the birds acquired complete immunity.

The E. brunetti immunity pattern was strikingly different from that found for the other test species. Immunity toward this species developed rapidly in the birds, but toward the end of each study an apparent loss of immunity toward this species was noted. This loss was slight in the 1952 study, but was much more apparent in both 1953 studies, since many cases of clinical coccidiosis developed in the test chickens after challenge with E. brunetti.

Immunity testing with E. necatrix was carried out only toward the end of the 1952 study. All of the birds tested showed some degree of immunity toward this species.

It is difficult to ascertain the effect the weather played in determining the initial appearance, as well as peaks of incidence and intensity of the species encountered. E. tenella infections were apparently subdued during the hot part of the year, for no infections with this species were noted on the Steele farm during July of either year. The results for the Parks farm were affected by the build-up which occurred in the chicken house during the initial infections. E. maxima developed best during the hottest part of the year, since it did not appear in any study until July. The other four species encountered were, apparently, not affected by temperature. The relatively small amount of precipitation during 1953 undoubtedly contributed to the relative scarcity of infections that season as contrasted to 1952.

One hundred and five of the 207 chickens examined during these studies were found to have coccidial infections, as proved by passage of oocysts during the five-day examination periods. Only 50 of the 105 infections involved a single species. Most of the uni-specific infections developed either early in the studies, before some of the other species had appeared, or late in the season, after varying degrees of immunity had developed toward other species. Twenty-nine of the multiple-specific infections involved two species, 18 involved three species, and eight were quadruple infections.

Comparison of incidence and severity records for the three breeds of chickens used in these studies failed to reveal any significant difference in susceptibility to any of the coccidial species encountered. More severe infections, however, might have revealed differences in the clinical effects.

During 1953, a listing was made of other intestinal parasites of the chickens encountered in the post-mortem examinations which were made after completion of the challenging tests. Seven other animal parasites were found in the chickens from each farm. These parasites included two tapeworms, Hymenolepis carioca and Raillietina cesticillus; two nematodes, Ascaridia galli and Heterakis gallinae; and three protozoa, Trichomonas sp., Chilomastix gallinarum, and Entamoeba gallinarum.

MASTERS' THESES

Accepted July 1, 1954 - June 30, 1955 = 184

The following summaries and indices may prove helpful to those interested in tabulations and to those who wish to examine theses in the same or related fields. Two copies of each thesis are on file in the Iowa State College Library.

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